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AFFDL-TR-72-101 - Vol II

EXPERIMENTAL AND ANALYTICAL DETERMINATION OF INTEGRATED AIRFRAME NOZZLE PERFORMANCE

Operating Manual for Twin-Nozzle/Aftbody Drag and
Internal Nozzle Performance Computer Deck

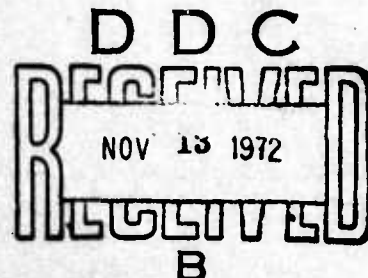
E. R. GLASGOW, D. M. SANTMAN, AND L. D. MILLER, et al
LOCKHEED-CALIFORNIA COMPANY

TECHNICAL REPORT AFFDL-TR-72-101 - VOL II

OCTOBER 1972

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EXPERIMENTAL AND ANALYTICAL DETERMINATION OF INTEGRATED AIRFRAME NOZZLE PERFORMANCE

**Operating Manual for Twin-Nozzle/Aftbody Drag and
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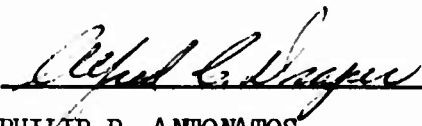
FOREWORD

The computer program described herein was developed by the Lockheed-California Company (Calac), Burbank, California, under Contract No. F33657-70-C-0511 of Project No. 668A. The contract was administered by the Air Force Flight Dynamics Laboratory (AFFDL), Wright-Patterson Air Force Base, Ohio, with P.C. Everling (FXM) and J.A. Laughrey (FXM) as Project Engineers. Subcontract support was provided by Pratt and Whitney Aircraft (P&WA), East Hartford, Connecticut.

This is the second of a two-volume final report to be submitted under the contract which was conducted during the period from 1 November 1969 to 31 July 1972. The report describes the operation of the end item computer program developed for predicting twin-nozzle/aftbody drag and internal nozzle performance. In addition to the three principal authors, R.A. Fox and R.D. Grennan of Calac made significant contributions toward preparation of the report manuscript. The authors are indebted to the following Calac personnel for their assistance in developing the computer program: E.L. Bragdon and M.H. Scott, Jr., of Propulsion; R.F. Smith of Aerodynamics; and T.J. Jones, B.A. Schwartz, and D.A. Tappeiner of Computer Services.

This report was submitted by the authors for AFFDL approval on 31 July 1972. A Calac report number, LR 25370, has been assigned to identify the report prior to approval.

This technical report has been reviewed and is approved.


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ABSTRACT

A computer program has been developed for predicting twin-nozzle/aftbody drag and internal nozzle performance for fighter type aircraft having twin buried engines and dual nozzles. The program is capable of generating the installed thrust-minus-drag data required for conducting mission analysis studies of aircraft of this type. The configuration variables which can be analyzed include (1) nozzle type (convergent flap and iris, convergent-divergent with and without secondary flow, and shrouded and unshrouded plug), (2) nozzle lateral spacing, (3) interfairing type (horizontal and vertical wedge), (4) interfairing length, and (5) vertical stabilizer type (single and twin).

The performance prediction methods incorporated in the program are based almost entirely on empirical correlations. Specifically, correlations used in conjunction with one-dimensional flow relationships are employed for the prediction of the nozzle thrust and discharge coefficients, and correlations of the test data obtained during the contracted effort are employed for prediction of the aft-end drag. The prediction methods account for the effects of nozzle pressure ratio and flow separation on both internal and external nozzle surfaces.

This manual describes the operation of the computer program in terms of program input requirements, performance prediction methods, and output format and includes a presentation of sample input/output cases and a complete computer listing of the program. The program has been developed for use on the CDC 6600 computer.

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LIST OF SYMBOLS

A_e	Physical nozzle exit area
$A_{e_{flow}}$	Flow area at nozzle exit
$A_{e_{sep}}$	Flow area at separation point
A_F	Frontal area
A_M	Maximum cross-sectional area
A_{MB}	Metric break cross-sectional area
A_S	Shroud area (jet plus base areas)
A_T^*	Flow area for sonic flow
A_W	Wetted surface area
$C_{D_{A_S}}$	Boattail pressure drag coefficient based on boattail cross - sectional area at nozzle exit station.
C_{d_N}	Nozzle discharge coefficient
$C_{d_{N_{max}}}$	Maximum nozzle discharge coefficient
$C_{D_{PT}}$	Boattail pressure drag coefficient based on shroud cross - sectional area at nozzle exit station.
$C_{D_{PT}}$	Boattail pressure drag coefficient based on maximum boattail cross - sectional area
C_f	Skin friction coefficient

LIST OF SYMBOLS (CONTINUED)

C_S	Stream thrust correction factor
C_T	Thrust coefficient
D	Drag
F_{id}	Ideal gross thrust based on isentropic expansion of actual flow to freestream pressure
IMS	Integral Mean slope
K	Drag due to lift factor
L_{BT}	Boattail length
L_{eff}	Effective flat plate length
m	Mass flow rate
M_e	Exit Mach number
M_{sep}	Mach number upstream of separation point
M_T	Throat Mach number
P	Static pressure
P_b	Base pressure
P_{sep}	Static pressure upstream of separation point
P_{T_e}	Total pressure at nozzle exit
P_{T_T}	Total pressure at nozzle throat
$(P_{T_T}/P_\infty)_{CK}$	Choking pressure ratio
$(P_{T_T}/P_\infty)_{CR}$	Critical pressure ratio
$(P_{T_T}/P_\infty)_F$	Pressure ratio at which the nozzle flows full

LIST OF SYMBOLS (CONTINUED)

$(P_{T_T}/P_{\infty})_L$	Pressure ratio where linear C_T extrapolation ends
q	Dynamic pressure
R_c	Lip radius of curvature
$R_{e\theta}$	Momentum thickness Reynolds number
R'_e	Reference Reynolds number
R_{mf}	Momentum ratio
R	Radius
T_{aw}	Adiabatic wall temperature
μ	Viscosity
α	Nozzle upstream approach angle
θ	Internal divergence angle
γ	Ratio of specific heat values

SUBSCRIPTS

b	Base
$C-D$	Convergent-Divergent
$CONV$	Convergent
e	Exit
EB	Equivalent body
L	Local
P	Primary flow
S	Secondary flow
T	Throat

NOZZLE SYMBOLS

CD	Convergent - divergent
CDE	Convergent - divergent ejector
CF	Convergent flap
CI	Convergent iris
SP	Shrouded plug
UP	Unshrouded plug

SECTION 1

INTRODUCTION

This manual presents a detailed description of the Twin-Nozzle/Aftbody Drag and Internal Nozzle Performance Computer Program. This program was developed under Contract F33657-70-C-0511, Program for Experimental and Analytical Determination of Integrated Airframe-Nozzle Performance.

The purpose of this manual is to describe in detail the capabilities and limitations of the program, the numerical methods used, and the operational procedures required to run the program. The computational procedures are presented both in the form of detailed descriptions and flow charts summarizing the methods. The input instructions consist of a description of each input required and how the input is to be implemented. The output section consists of a description of the output format and an explanation of error messages that are included. Finally, a description of the operational setup needed for program execution is provided including control cards, deck assembly instructions, and necessary external routines.

The capabilities and restrictions of the program including a flow-chart are presented in Section 2. The computational methods used to predict aft-end drag and internal nozzle performance are discussed in Section 3; and the operating instructions, consisting of user and programmer inputs and the output summary, are included in Section 4. Sample cases including examples of input coding sheets and a complete listing of the program are provided in appendixes.

SECTION 2

COMPUTER PROGRAM CAPABILITIES

2.1 GENERAL DESCRIPTION OF PROGRAM

The program consists of a main control routine, three nozzle internal performance subroutines, and an aft-end drag subroutine. The prediction methods incorporated in these subroutines are based almost entirely on empirical correlations. Specifically, correlations developed by P&WA (Reference 41) are employed for prediction of nozzle thrust and discharge coefficients, and correlations of Phase II test data are employed for prediction of twin-nozzle/aftbody drag. The predicted aft-end drags for a subsonic external flow must be used with caution if the user employs the aftbody maximum area station as the reference station for drag accounting since the aftbody metric break station of the Phase II model lies downstream of the maximum area station. Using the maximum area station as a reference station requires in some cases a procedure for obtaining the drag acting on the body between the maximum area and metric break stations. This drag increment is very small for subsonic external flow and may be neglected. For supersonic external flow, a procedure for obtaining this drag increment was developed and incorporated in the aft-end drag routine to predict the boattail drag aft of the maximum area station. The components of the aft-end drag include boattail pressure and friction drags and annular base drag.

Since the empirical correlations are based on Phase II data and little data was obtained in the 0.9 to 1.2 Mach number range, the predicted aft-end drags for this Mach regime should also be used with caution.

The program will analyze the following five types of nozzles: convergent, convergent-divergent, convergent-divergent ejector, unshrouded plug, and shrouded plug. The nozzle routines yield values of thrust and discharge coefficients, as well as pumping characteristics for ejector nozzles.

There are basically two types of input to the program: fixed and variable. The fixed inputs are constant for a given series of cases and consist of geometrical inputs such as nozzle type and maximum area. The variable inputs may change from case to case and consist of geometrical inputs, such as nozzle area ratio, and operating conditions such as freestream Mach number and nozzle pressure ratio. For most of the variable inputs, the user has the option of using direct input values or having the program read a curve.

2.2 COMPUTER PROGRAM LOGIC

The overall logic of the program is illustrated by the flow charts shown in Figure 1. The program consists of a main control routine, three internal

performance subroutines, and an aft-end drag subroutine. Upon reading and processing of the input the appropriate internal flow routine is selected based on the nozzle type. Convergent and convergent-divergent nozzle cases are analyzed using subroutine NOZZLE, convergent-divergent ejector cases use subroutine EJECTR, and plug nozzle cases use subroutine NOZPLG. When running convergent-divergent, convergent-divergent ejector and shrouded plug nozzles, the user has the option of varying the nozzle internal expansion ratio between two input limiting values in order to obtain the maximum thrust-minus-drag for a given throat area. In all cases, the user has the option of providing either the physical throat area or the flow area at the throat. The area which is not specified as the input is obtained from the other area and the nozzle discharge coefficient.

The nozzle performance subroutines can analyze various internal flow regimes depending on the nozzle type. For convergent nozzles, separate prediction methods are employed when the throat flow is subsonic, the throat flow is critical but not choked (nozzle pressure ratio where the discharge coefficient is invariant with nozzle pressure ratio), and the flow is critical and choked. For convergent-divergent and convergent-divergent ejector nozzles, separate prediction methods are employed when the flow is subsonic throughout the nozzle, the flow is critical with separation occurring in the divergent section, and the flow is critical with no internal flow separation. Thrust and discharge coefficients for these nozzles are computed using one-dimensional flow relationships combined with empirical correction factors. The one-dimensional compound flow analysis of Bernstein (Reference 45) is employed for predicting ejector pumping characteristics.

The method employed for computing plug nozzle thrust coefficients depends on the freestream Mach number. Specifically, for a subsonic external flow, correlations involving plug pressure forces are employed which, when combined with the gross thrust at the nozzle exit, yield plug nozzle thrust coefficients. For a supersonic freestream Mach number, plug surface pressure forces are computed using an approximate construction of the expansion fan generated by the flow expansion around the cowl lip. The plug base pressure correlation is also employed for the supersonic case. Plug nozzle discharge coefficients are computed using correlations of Phase I test data.

The aft-end drag subroutine calculates the three components of the total aft-end drag of the aircraft: boattail pressure drag, boattail friction drag, and annular base drag. The routine tests the flight speed to determine whether to call the subsonic or supersonic boattail and base drag methods. Three separate correlations are employed for predicting the boattail pressure drag for a subsonic external flow: jet-off drag correlations, correlations of the drag increment from jet-off to the nozzle design pressure ratio, and correlations of the drag increment from the design pressure ratio to operation at a higher pressure ratio. The first two correlations are based on nozzle/aftbody geometry while the last correlation is based on nozzle underexpansion losses. For supersonic external flow, jet-off drag correlations and correlations of the drag increment from jet-off to the operating pressure ratio are employed.

SECTION 3

DISCUSSION OF METHODS

This section describes the methods employed for predicting twin-nozzle/aft-body drag and internal nozzle performance. The external drag methods consist primarily of the empirical correlations whose development is described in Volume I of this report (Reference 89). The nozzle internal performance methods are basically those developed by P&WA which are described in Reference 41.

3.1 TWIN-NOZZLE/AFTBODY DRAG

The computational methods employed for predicting boattail pressure and friction drags and annular base drag are presented in this subsection. All methods are based on empirical correlations of wind tunnel data and, except for the friction drag routine, are different for subsonic and supersonic speeds.

3.1.1 Boattail Pressure Drag

3.1.1.1 Subsonic Flow

This subsection present the methods for predicting the boattail drag aft of the metric break station for Mach numbers less than 1.0. The boattail drag coefficient referenced to the cross-sectional area at the metric break station (A_{MB}) is computed from the following empirical correlation of the Phase II data.

$$C_{D_{PT}} = K_1 \left(\frac{IMS}{M_\infty} \right)^{2/3} \frac{A_F}{A_{MB}} + K_2 \frac{A_S}{A_{MB}} + \frac{K_3 F_{id}}{q_\infty A_{MB}} \quad (1)$$

where

$$K_1 = \hat{C}_{D_{PT}} \left(\frac{M_\infty}{IMS} \right)^{2/3} \quad (2)$$

$$K_2 = \Delta C_{D_{A_S}} \quad (3)$$

and

$$K_3 = \frac{\Delta D}{F_{id}} \quad (4)$$

A_F is the projected boattail frontal area, $(A_{MB} - A_S)$, A_S is the shroud area for both nozzles (sum of jet and base areas) and F_{1d} is the ideal thrust of the twin jet model obtained by isentropic expansion of the exhaust flow to free-stream pressure. The first term in Equation 1 is the jet-off drag, the second term is the drag increment when going from jet-off to operation at the nozzle design pressure ratio and the third term represents the drag increment when going from design pressure ratio operation to operation at a higher pressure ratio. The design pressure ratio for convergent and convergent-divergent nozzles is defined as that pressure ratio associated with a cylindrical plume (static operation) and with critical throat flow. For unshrouded plug nozzles, the design pressure ratio is set equal to the design pressure ratio of a convergent nozzle.

The jet-off drag coefficient parameter, K_1 , is presented in Figures 2 through 4 for the narrow, intermediate, and wide nozzle lateral spacings with horizontal interfairings and a single vertical tail. The drag parameter is obtained from these figures through use of the integral mean slope (IMS) of the equivalent body of revolution and the shroud to metric break area ratio (A_S/A_{MB}). The correlation results shown in Figures 2 through 4 are applicable for all nozzle configurations except the narrow-spaced normal-power convergent-flap configuration. Correlation results for this configuration are presented in Figure 5. Correlation results for narrow spaced configurations with vertical interfairings are presented in Figure 6. Figure 7 presents correlation results for wide spaced configurations with twin vertical tails. A linear interpolation and extrapolation for area ratios other than those presented in the figures is employed.

The drag parameter, K_2 , for determining the increment in drag when going from jet-off to jet-on at the nozzle design pressure ratio is presented in Figures 8 through 10 for narrow, intermediate and wide nozzle lateral spacings and for Mach numbers ranging from 0.6 to 0.9. This drag increment is presented in terms of an increment in drag coefficient referenced to the twin nozzle shroud exit area (sum of jet and base areas) and is correlated as a function of boattail trailing edge θ_E , at the nozzle exit. The results shown in the figures are applicable for all configurations.

For convergent and convergent-divergent nozzle installations, the drag parameter, K_3 , which is the increment in drag when going from design pressure ratio operation to operation at a higher pressure ratio, is presented in Figures 11 through 13 as a function of the nozzle underexpansion loss. The drag increment, which is normalized by the ideal thrust, is dependent on both the Mach number and shroud exit to metric break area ratio. Figure 14 and 15 present the drag parameter, K_3 , for the normal and maximum A/B plug nozzles, respectively. The drag parameter in these figures is presented as a function of a reference convergent nozzle underexpansion loss.

3.1.1.2 Supersonic Flow

This subsection presents the methods for predicting the boattail drag aft of the maximum area (exclusive of wing) station for Mach numbers greater than

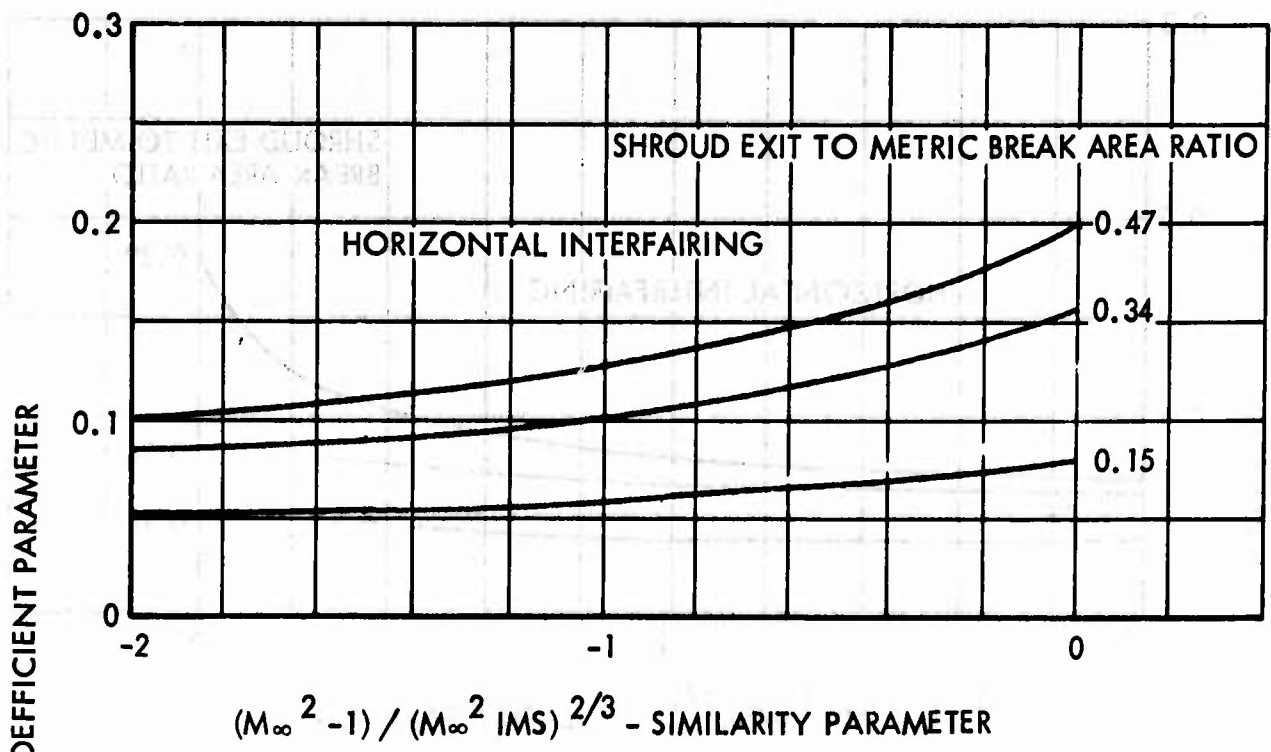


Figure 2. Transonic Similarity Correlation of Jet-Off Total Boattail Drag - Narrow Spacing

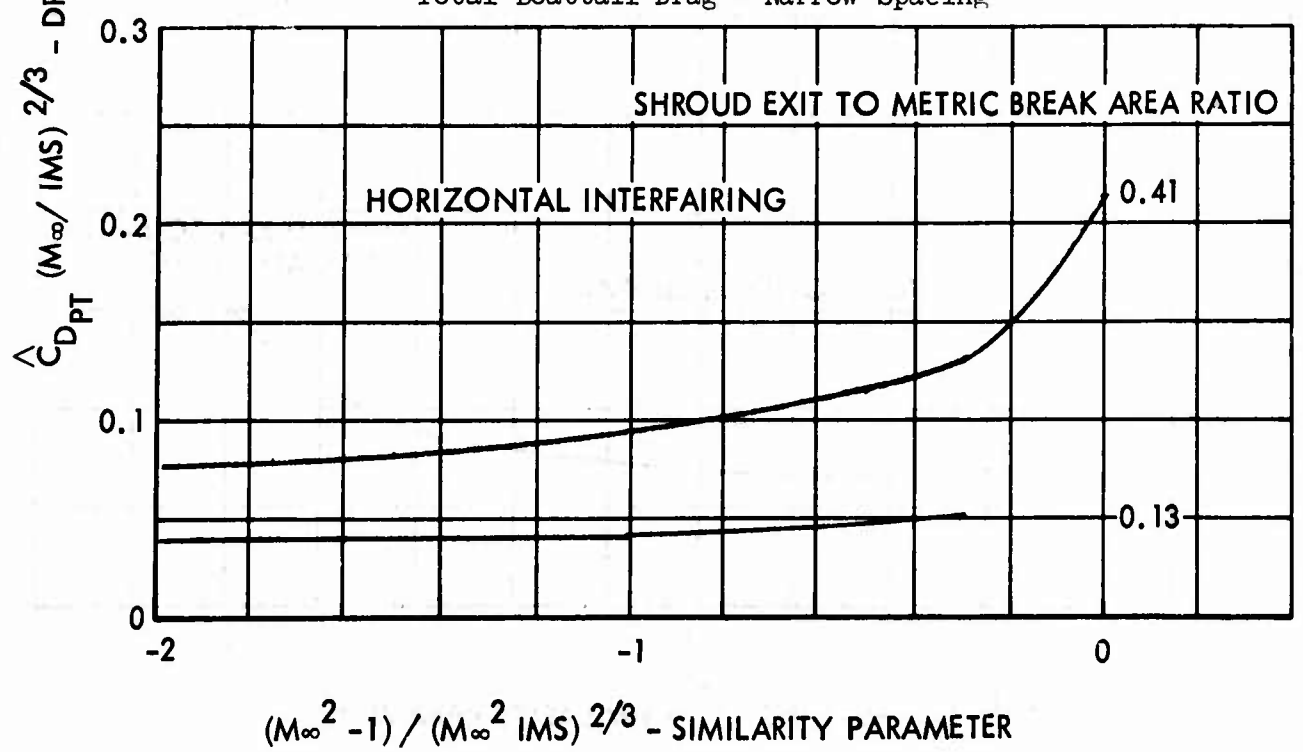


Figure 3. Transonic Similarity Correlation of Jet-Off Total Boattail Drag - Intermediate Spacing

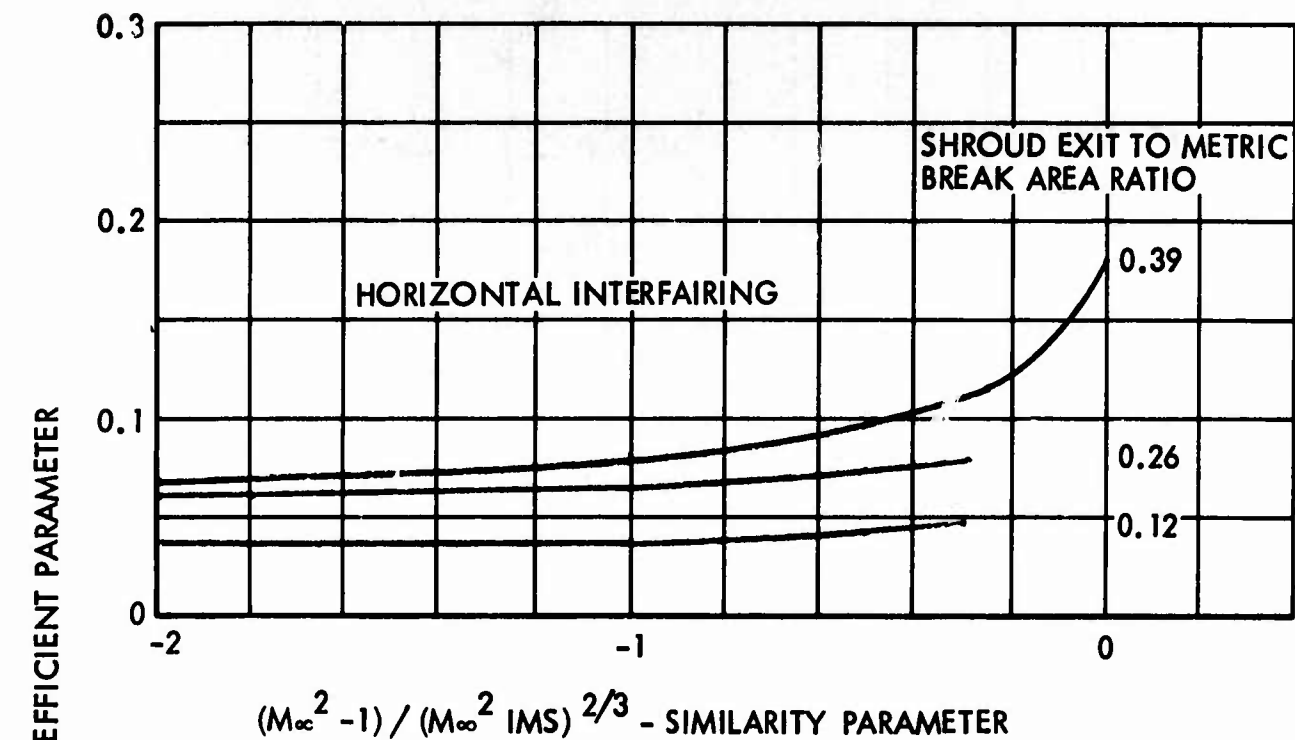


Figure 4. Transonic Similarity Correlation of Jet-Off Total Boattail Drag - Wide Spacing

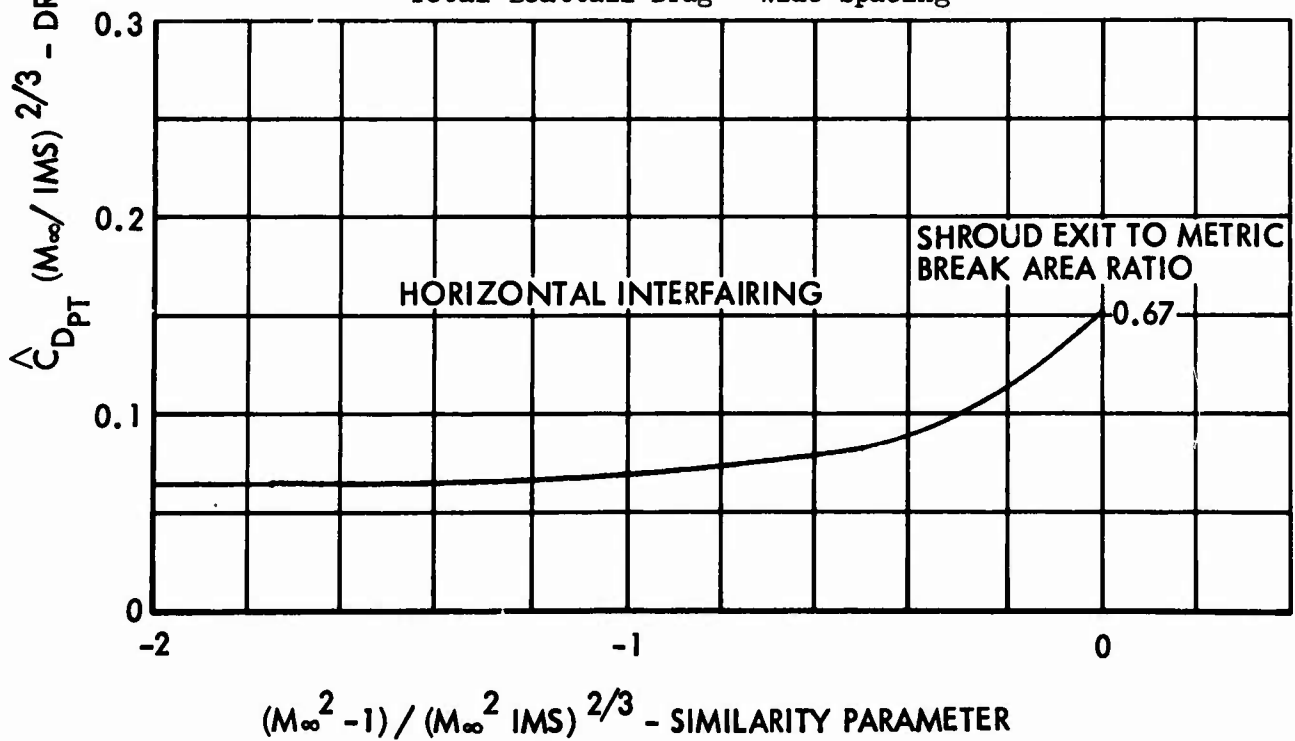


Figure 5. Transonic Similarity Correlation of Jet-Off Total Boattail Drag - Narrow Spacing - Convergent Flap Nozzle

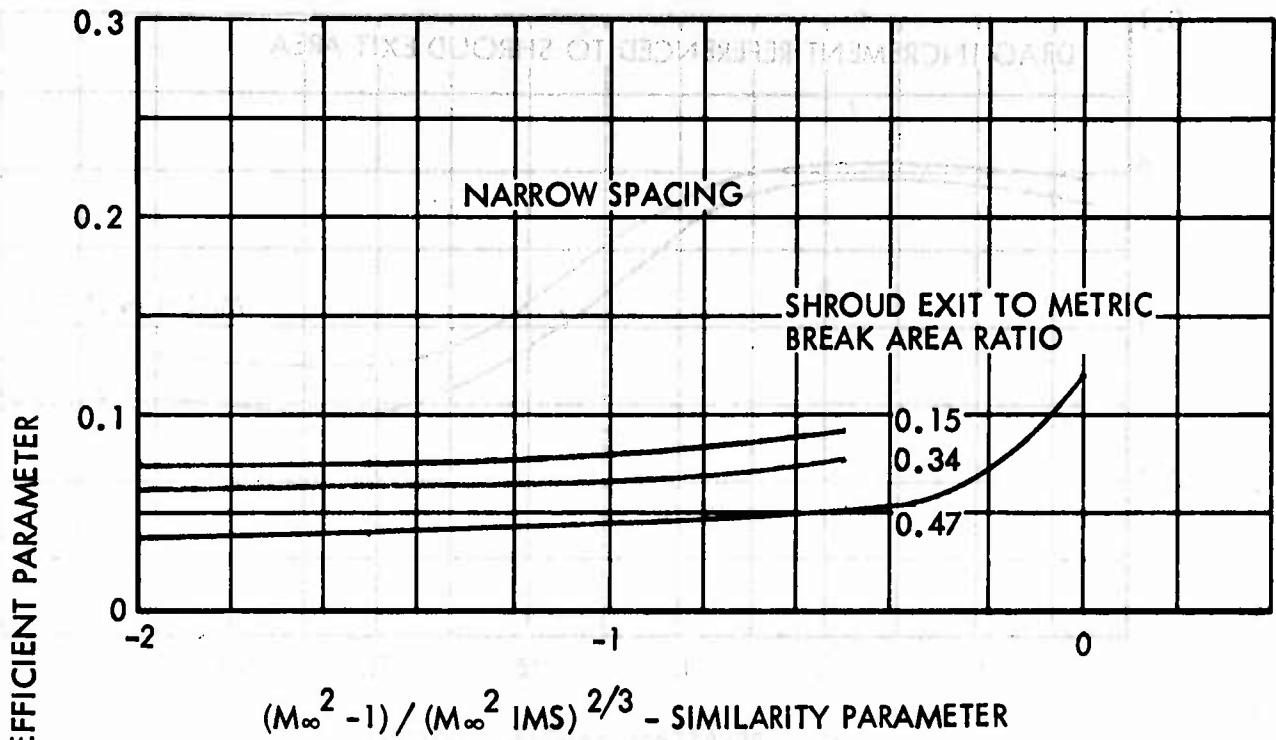


Figure 6. Transonic Similarity Correlation of Jet-Off Total Boattail Drag - Vertical Interfairing

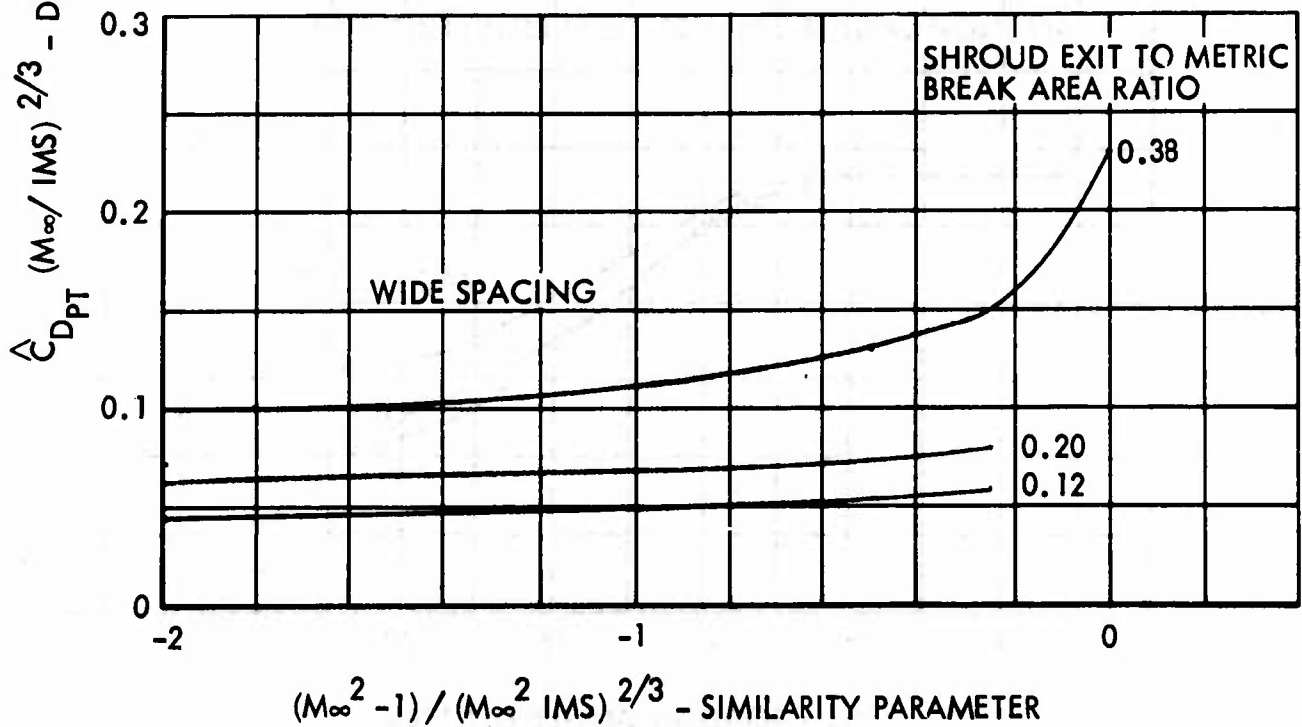


Figure 7. Transonic Similarity Correlation of Jet-Off Total Boattail Drag - Twin Vertical Tails

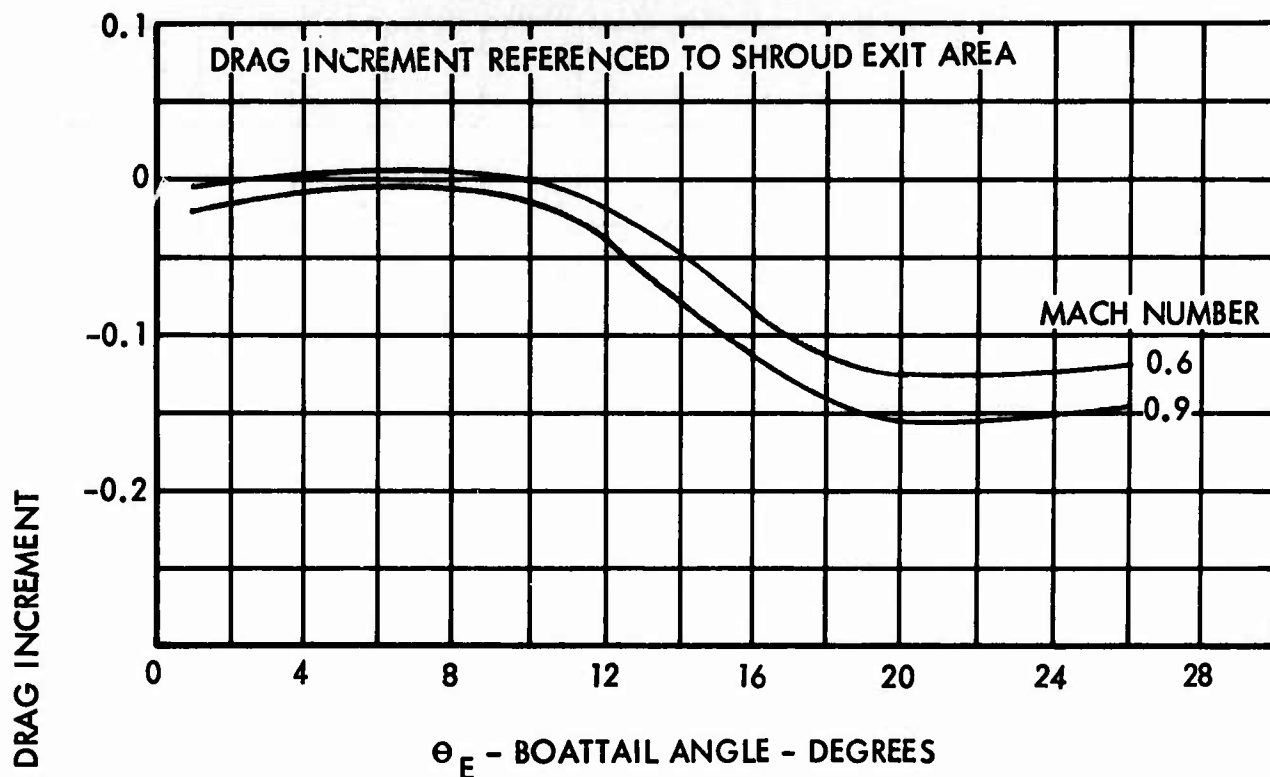


Figure 8. Correlation of Drag Increment From Jet-Off To Design Pressure Ratio - Narrow Spacing

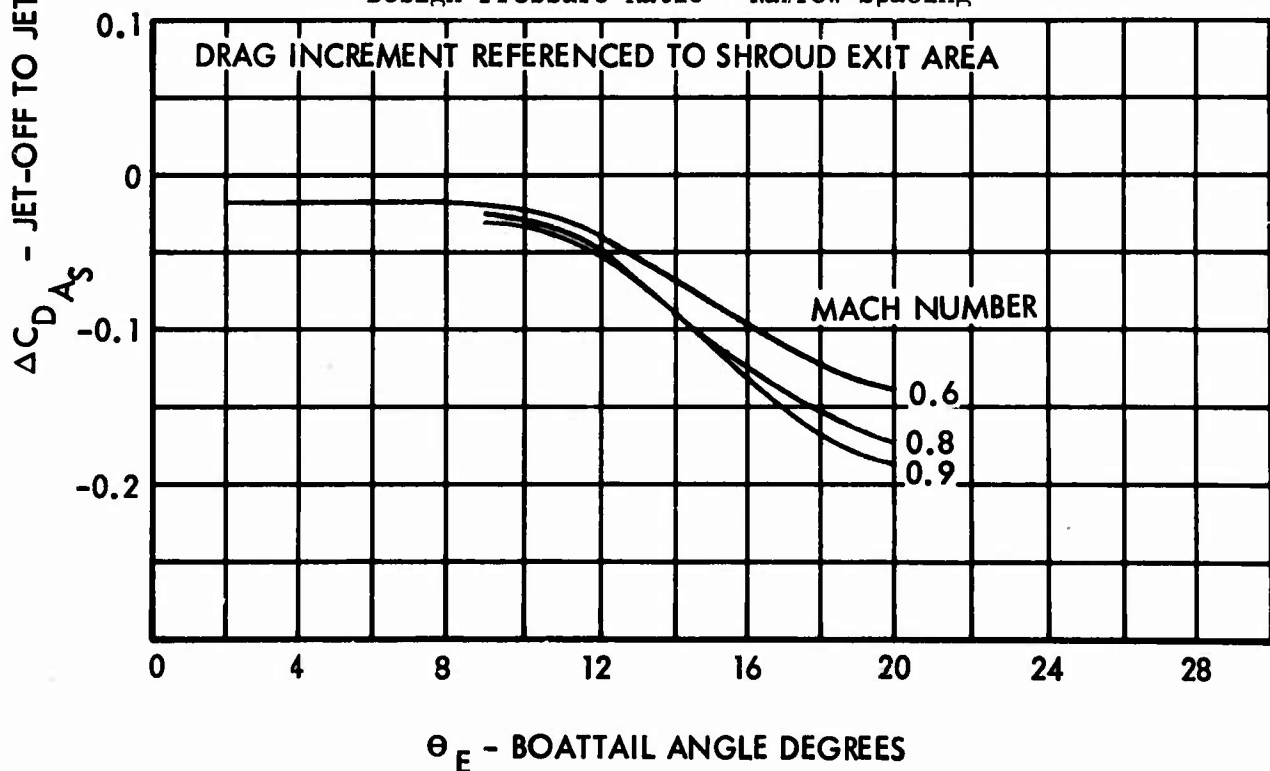


Figure 9. Correlation of Drag Increment From Jet-Off To Design Pressure Ratio - Intermediate Spacing

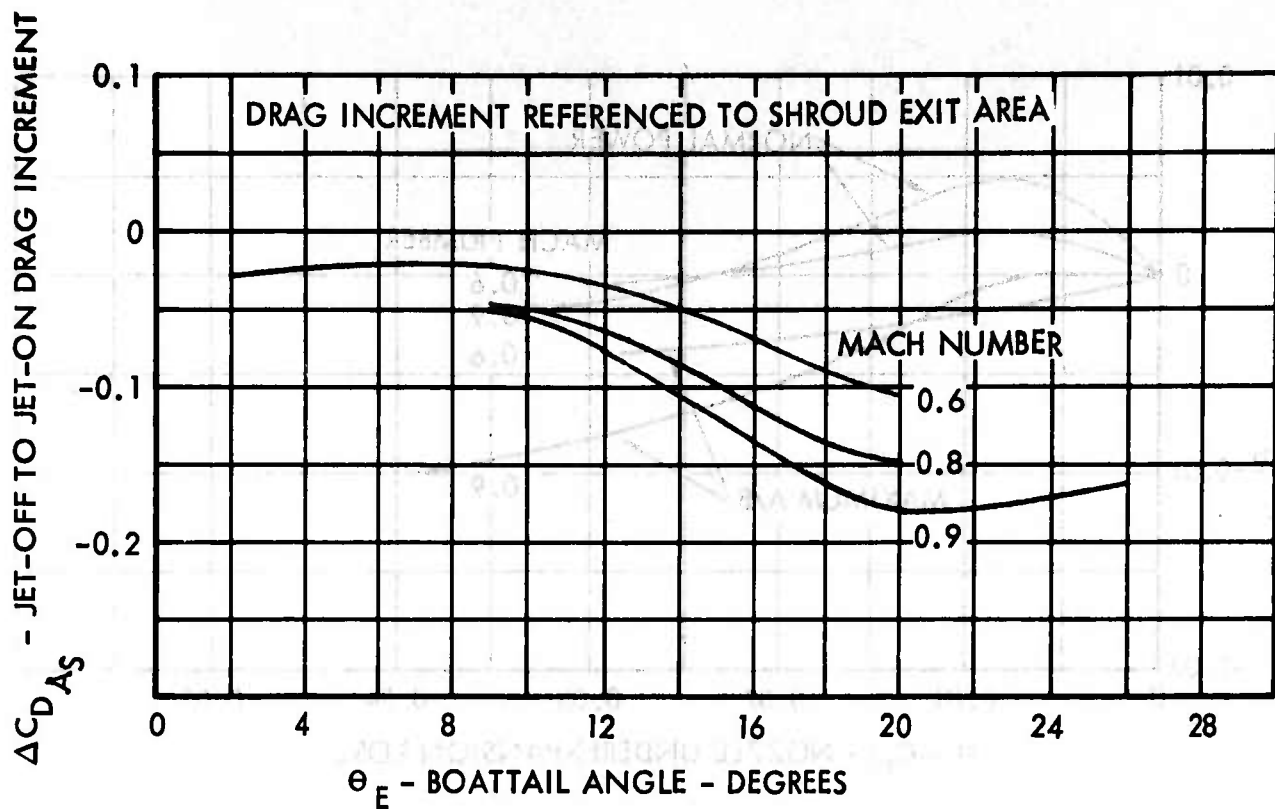


Figure 10. Correlation of Drag Increment From Jet-Off To Design Pressure Ratio - Wide Spacing

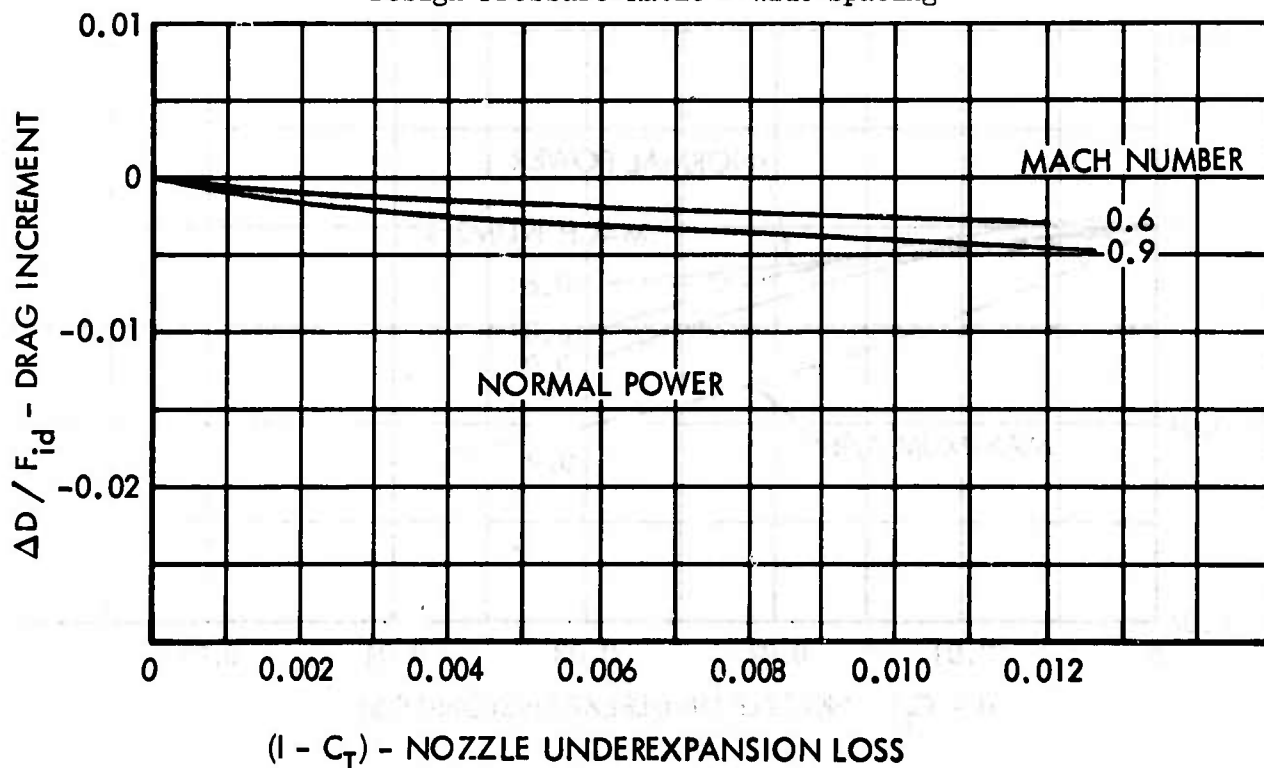


Figure 11. Correlation of Drag Increment From Design To Operating Pressure Ratio - Convergent-Divergent Nozzle

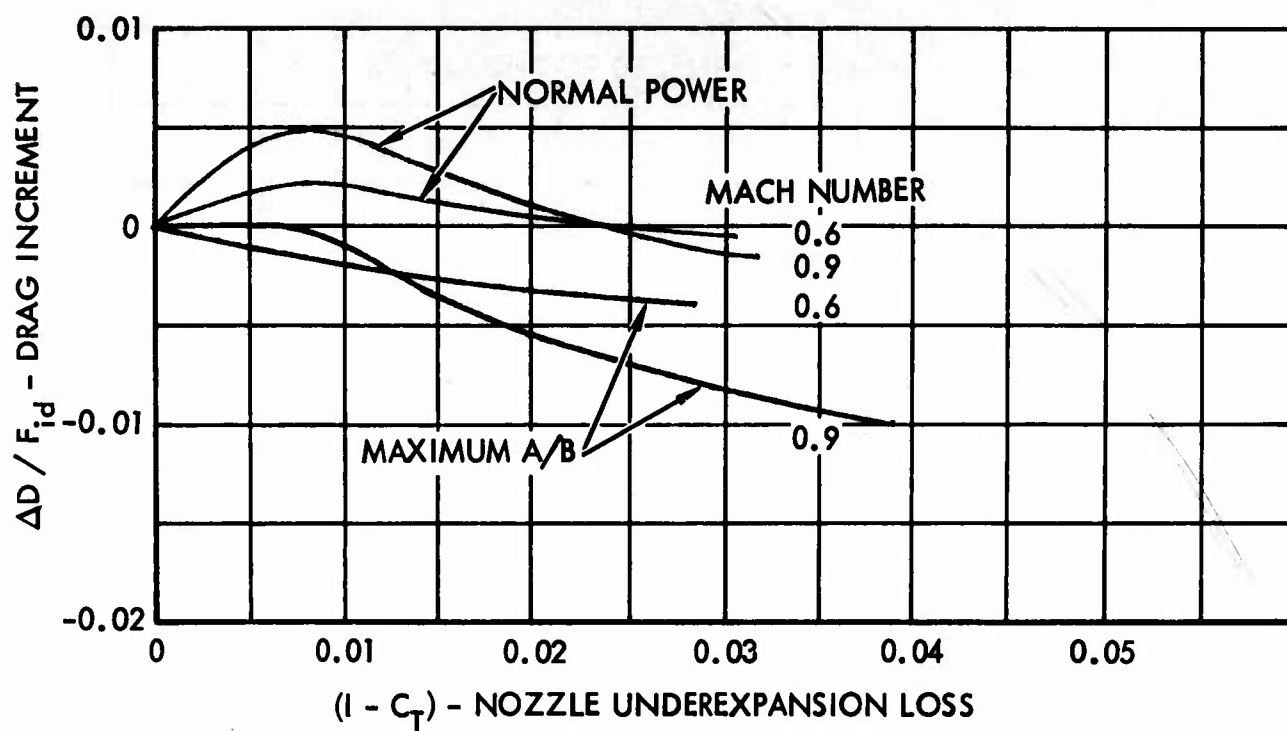


Figure 12. Correlation of Drag Increment From Design to Operating Pressure Ratio - Convergent-Flap Nozzle

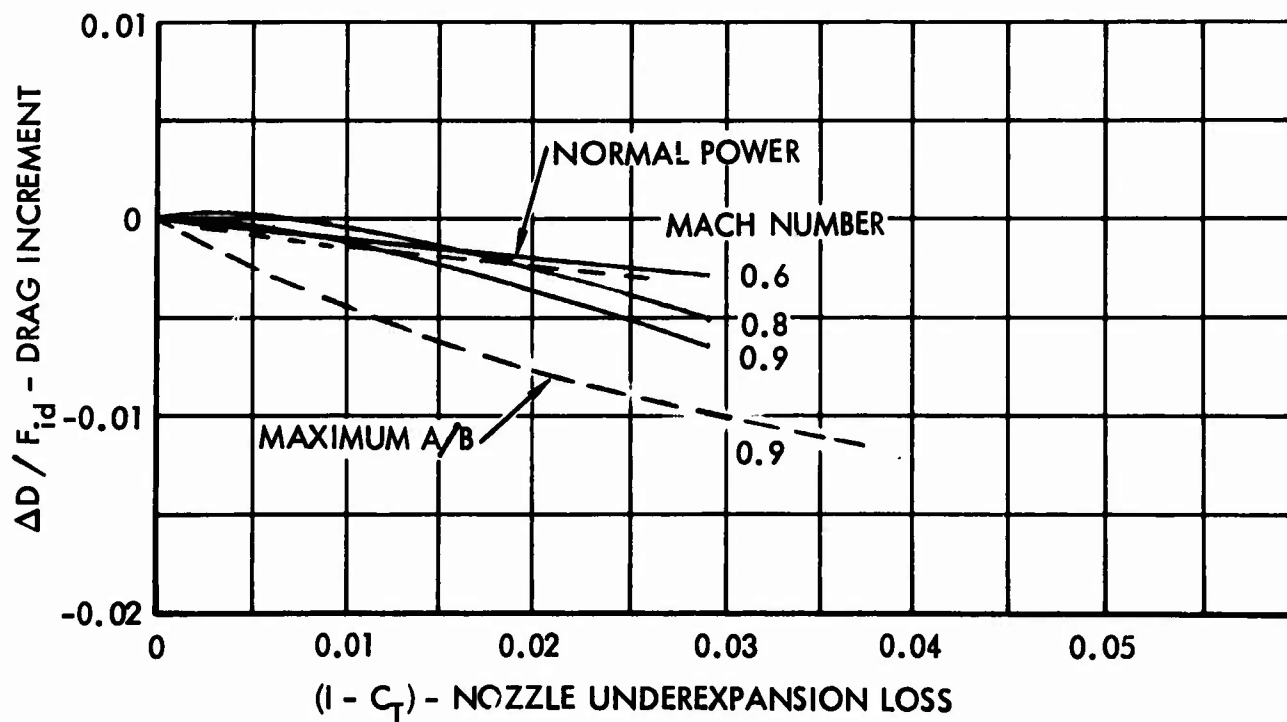


Figure 13. Correlation of Drag Increment From Design to Operating Pressure Ratio - Convergent-Iris Nozzle

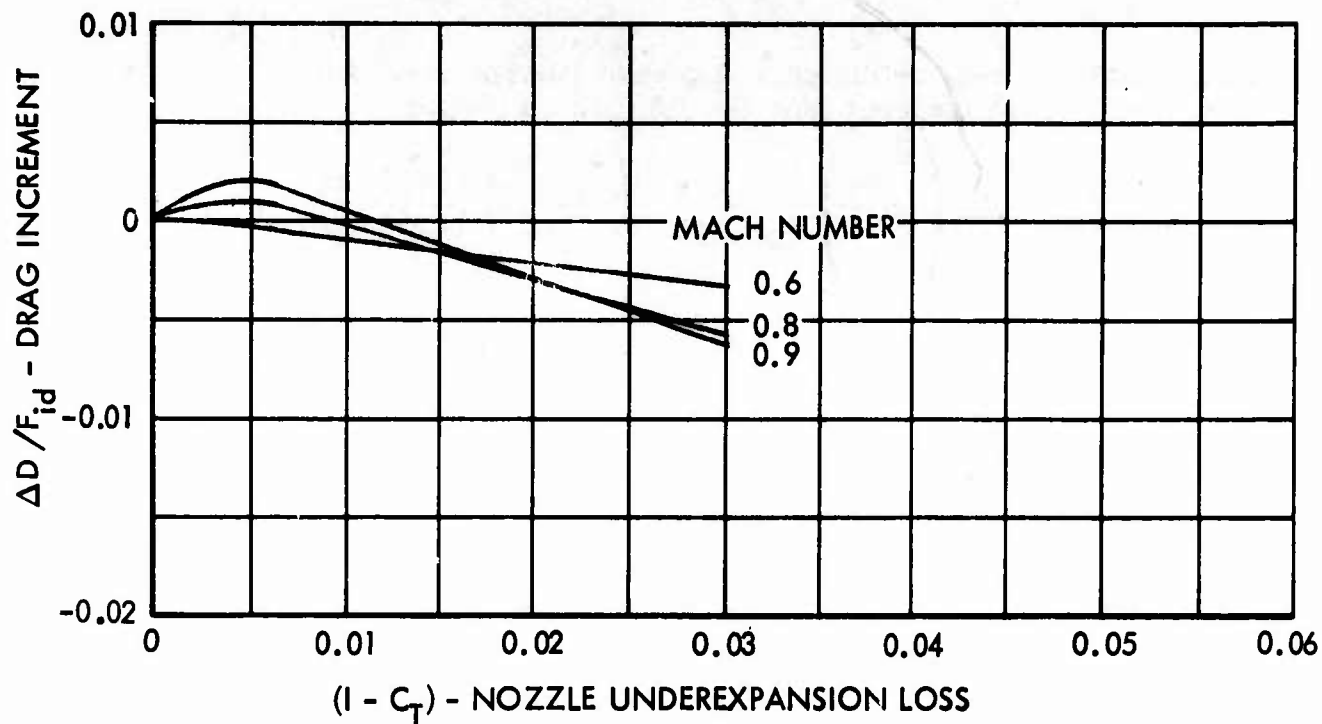


Figure 14. Correlation of Drag Increment From Design to Operating Pressure Ratio - Normal Power Plug Nozzle

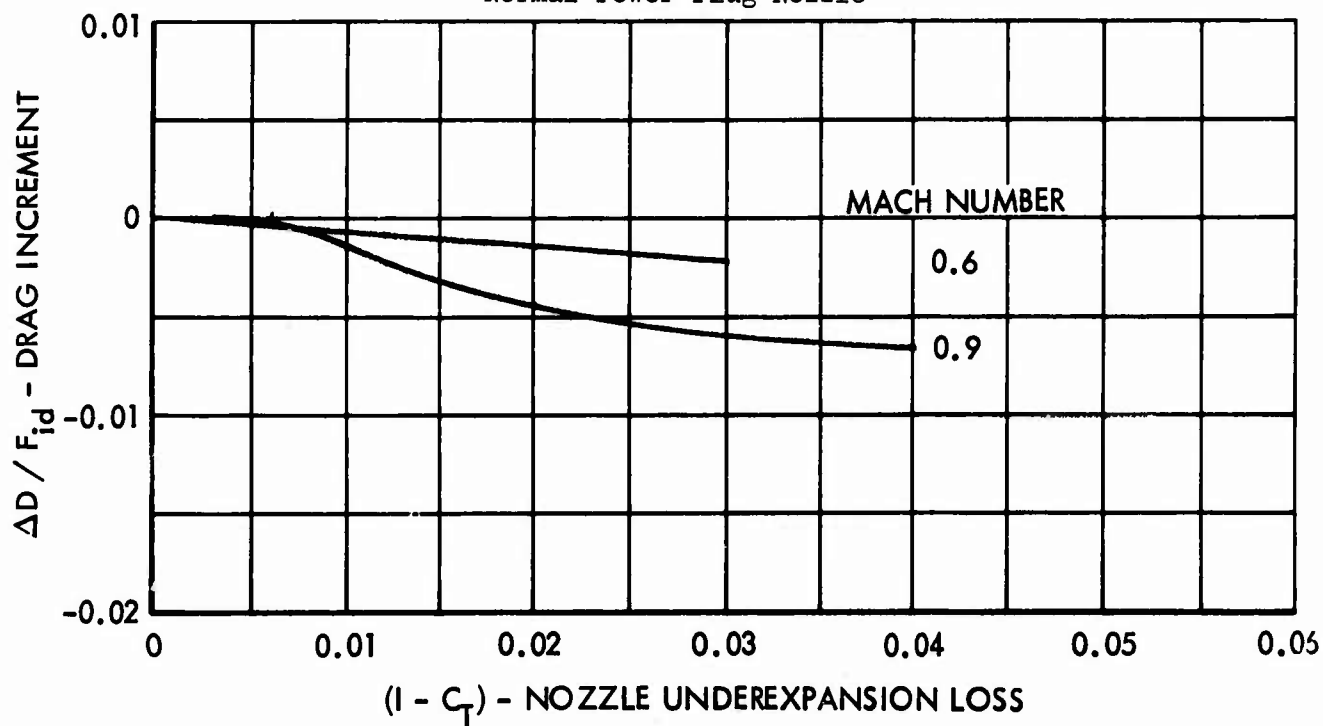


Figure 15. Correlation of Drag Increment From Design to Operating Pressure Ratio - Maximum A/B Power Plug Nozzle

1.0. Boattail drag coefficients, based on maximum area, for a supersonic external flow are computed from the following equation

$$C_{D_{PT}} = \hat{C}_{D_{EB}} \left(\frac{\hat{C}_{D_{PT}}}{\hat{C}_{D_{EB}}} \right) \frac{A_F}{A_M} + K_4 \left(\frac{P_e - P_L}{P_\infty} \right) \left(\frac{A_S}{A_M} \right) \left(\frac{P_\infty}{q_\infty} \right) \quad (5)$$

where the first term is the jet-off drag and the second term is the increment in drag when going from jet-off to jet-on operations.

The equivalent body drag is obtained by entering the method-of-characteristics boattail drag correlation curves presented in Figure 16 with the Mach number and IMS. The ratio of jet-off drag to equivalent body drag ($\hat{C}_{D_{PT}} / \hat{C}_{D_{EB}}$) is

obtained from the correlation results presented in Figure 17 as a function of Mach number and vertical stabilizer tape.

For jet-on operation, K_4 , which is the increment in drag from jet-off operation normalized by the product of the difference between the nozzle internal exit pressure and the local boattail surface pressure (assuming no flow separation), is obtained from Figure 18 as a function of nozzle mean boattail angle. The mean boattail angle used is the mean angle over a distance corresponding to one-third of the nozzle exit radius. This length was selected as being representative of the flow separation length. The local boattail flow properties are obtained from a method-of-characteristics solution (a large mesh size was employed to minimize computer time).

The correlation results presented in Figure 18 are restricted to pressure coefficients $(P_e - P_L)/q_L$ greater than 1.4. This pressure coefficient value was based on the empirical observation that little or no separation occurs for lower values. The results are also not applicable for Mach numbers greater than 1.6; a linear variation of K_5 with Mach number from the Mach 1.6 value to a K_5 value of zero at a Mach number of 2.0 is recommended.

3.1.2 Boattail Friction Drag

The required input for computation of the boattail friction drag is the boattail length (L_{BT}), the wetted surface area (A_w), and either the momentum thickness (θ) at the start of the boattail or an effective flat plate length (L_{eff}) upstream of the start of the boattail. With these inputs, an average boattail skin friction coefficient is computed by use of Sivells-Payne correlation (Reference 12) which, when combined with the wetted area, yields the friction drag as discussed below.

With an input momentum thickness at the start of the boattail the reference length Reynolds number, R'_{e1} , is obtained by iterative solution of the following equation

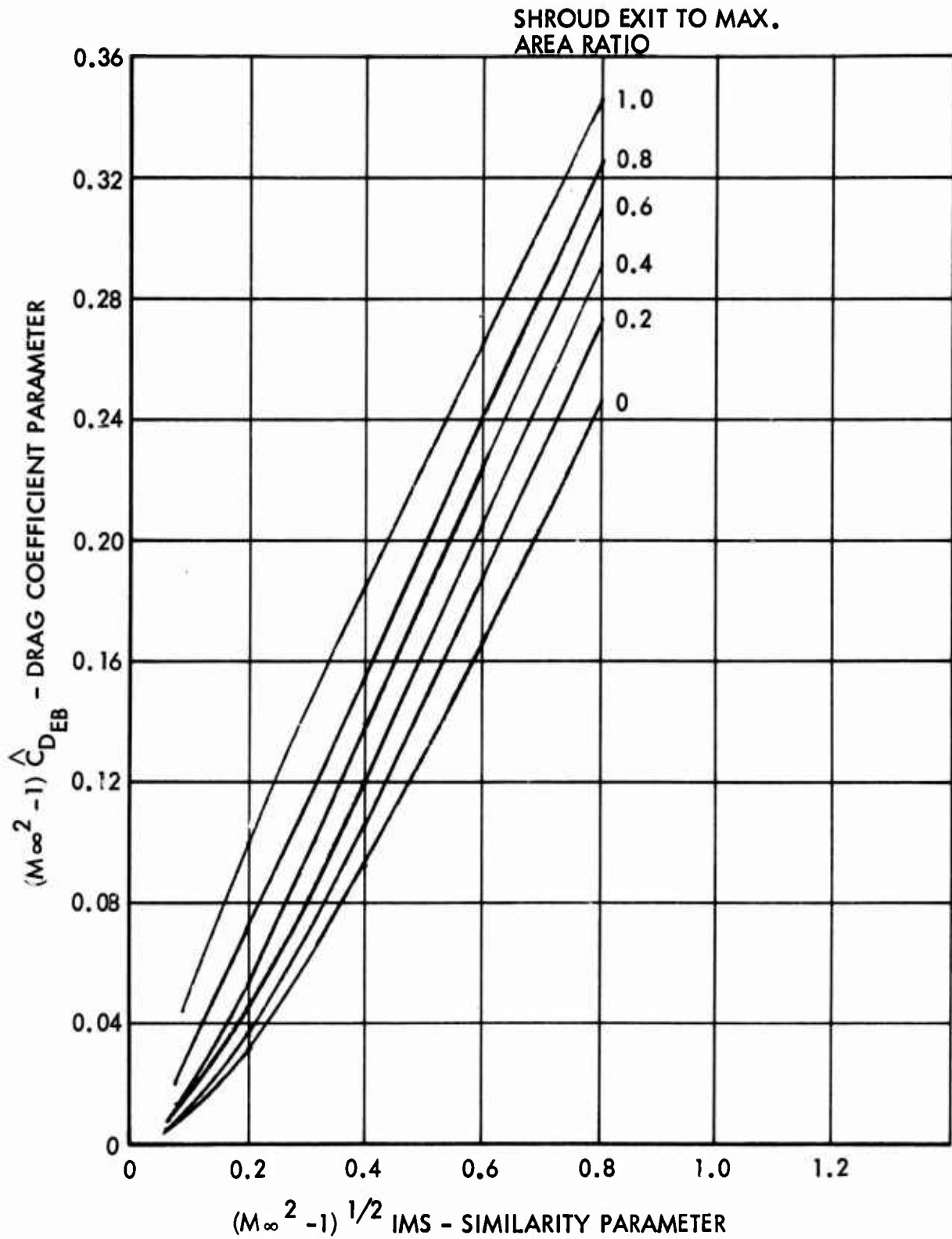


Figure 16. IMS/Supersonic Similarity Correlation Of
Method-Of-Characteristics Boattail Pressure
Drag

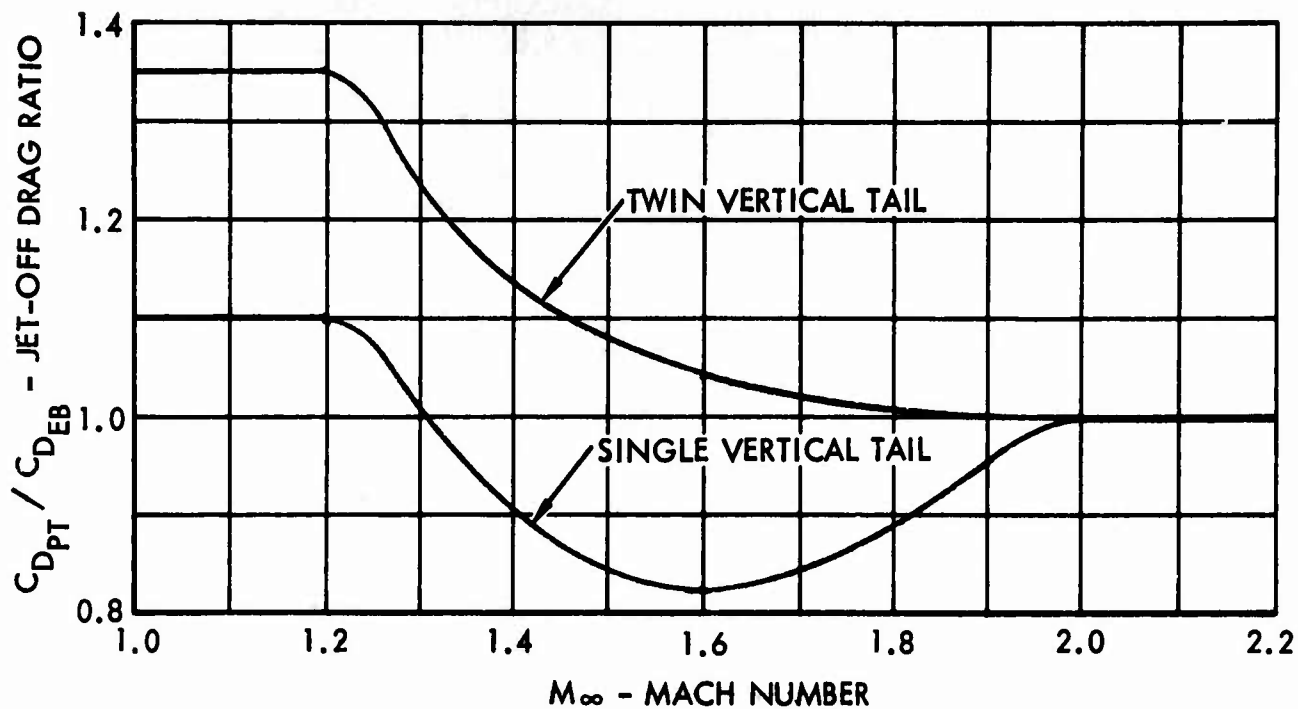


Figure 17. Equivalent Body Correlation Of Phase II Data

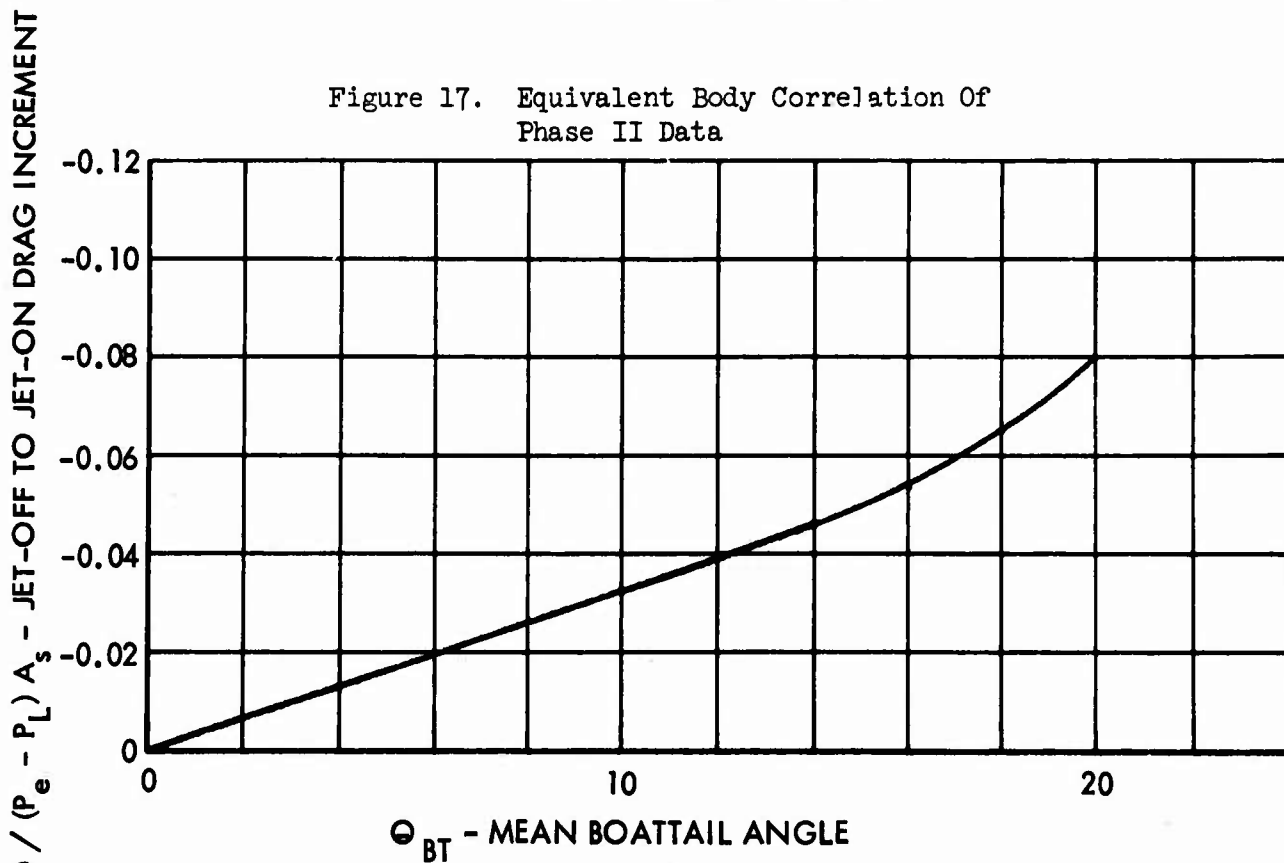


Figure 18. Correlation of Drag Increment From Jet-Off To Jet-On Operation - Supersonic Flow

$$Re_{\theta} = \frac{\mu_1'}{\mu_1} (0.044 Re_1') / (\log_{10} Re_1' - 1.5)^2 \quad (6)$$

where the primed quantities denote values evaluated at the reference temperature, T_1 , which is obtained from the following equation

$$T_1' = T_1 \left[1 + 0.035 M_{\infty}^2 + 0.45 \left(\frac{T_{aw}}{T_1} - 1 \right) \right] \quad (7)$$

where

$$T_{aw} = T_1 \left[1.0 + \left(\frac{\gamma-1}{2} \right) (0.89) M_{\infty}^2 \right] \quad (8)$$

If an effective flat plate length upstream of the boattail is input, the reference Reynolds number is obtained from the following equation:

$$Re_1' = \frac{\rho_1 U_{\infty} L_{eff}}{12g \mu_1'} \quad (9)$$

The local skin friction correlation equation taken from Reference 12 is

$$c_{f1} = \frac{0.088 (\log_{10} Re_1' - 2.3686)}{(\log_{10} Re_1' - 1.5)^3} \frac{T_1}{T_1'} \quad (10)$$

The local skin friction coefficient at the end of the boattail is computed in a manner similar to that described above except that the length employed in the computation of the reference length Reynolds number is

$$L_2 = L_{eff} + L_{BT} \quad (11)$$

If the momentum thickness Reynolds number is input, the effective flat plate length at the start of the boattail is computed as follows:

$$L_{eff} = \frac{12g \mu_1 Re_1}{\rho_1 U_{\infty}} \quad (12)$$

The skin friction drag coefficient based on maximum area is

$$C_{Df} = \frac{(C_{f1} + C_{f2})}{2} \frac{A_W}{A_M} \quad (13)$$

3.1.3 Annular Base Drag

The annular base pressure for a subsonic external flow is computed from the following modification (developed in Reference 89) of the Brazzel-Henderson base pressure correlation (Reference 33).

$$\frac{P_b}{P_\infty} = \frac{0.9 + 0.0167 (R_{mf})}{0.94 + 0.06 (A_S/A_M)} \quad (14)$$

where R_{mf} is the nozzle exit to freestream momentum ratio, defined as

$$R_{mf} = \frac{(MV)_e}{(MV)_\infty} = \frac{\gamma_e P_e A_e M_e^2}{\gamma_\infty P_\infty A_M M_\infty^2} \quad (15)$$

For a supersonic external flow, the following base pressure correlation developed by Brazzel-Henderson is also employed.

$$\begin{aligned} \frac{P_b}{P_\infty} = & \left[\frac{T_e}{T_e^*} \right] \left[\frac{3.5}{0.5 + 3.0 A_S/A_M} \right] \left[0.19 + 1.28 \left(\frac{R_{mf}}{1 + R_{mf}} \right) \right] \\ & + 0.047 (5 - M_\infty) \left[2 \left(\frac{\Delta X_e}{D_M} \right) + \left(\frac{\Delta X_e}{D_M} \right)^2 \right] \end{aligned} \quad (16)$$

The first term on the right side of Equation (16) normalizes the jet temperature to the jet temperature of a sonic nozzle. The second term corrects for boattail effects, and the third term is a correlation based on the ratio of nozzle exit momentum flux to freestream momentum flux. A nozzle position (relative to the end of the boattail) correction is obtained by the fourth term.

3.2 NOZZLE THRUST COEFFICIENT

This section describes the numerical methods employed for computation of nozzle thrust and discharge coefficients. Prediction methods for convergent, convergent-divergent, convergent-divergent ejector, and plug nozzles are described. The thrust coefficient is defined as the ratio of actual gross thrust to ideal gross thrust based on isentropic expansion of the actual mass flow to freestream pressure. The discharge coefficient is defined as the ratio of actual mass flow to ideal mass flow computed assuming one-dimensional sonic flow at the nozzle throat.

3.2.1 Convergent Nozzles

Convergent nozzle thrust coefficients are computed by use of the following equation,

$$C_T = \frac{C_S \left[\frac{P_e}{P_{T_T}} \frac{A_{e_{flow}}}{A_T^*} (1 + \gamma M_e^2) + \frac{P_e'}{P_{T_T}} \left(\frac{A_e}{A_T^*} - \frac{A_{e_{flow}}}{A_T^*} \right) \right] - \frac{P_\infty}{P_{T_T}} \frac{A_e}{A_T^*}}{F_{i_p} / (P_{T_T} A_T^*)} \quad (17)$$

where

$$\frac{F_{i_p}}{P_{T_T} A_T^*} = \left\{ \frac{2\gamma^2}{\gamma-1} \left(\frac{2}{\gamma+1} \right)^{\frac{\gamma+1}{\gamma-1}} \left[1 - \left(\frac{P_\infty}{P_{T_T}} \right)^{\frac{\gamma-1}{\gamma}} \right] \right\}^{1/2} \quad (18)$$

The term enclosed within the brackets in Equation 17 is the total momentum of the flow at the nozzle exit, normalized by $P_{T_T} A_T^*$.

The stream thrust correction factor, C_S , in the above equation is assumed to be 0.997. Equation 17 differs slightly from the equation presented in Reference 41 with the addition of the second term within the brackets. This term represents the pressure force (normalized by $P_{T_T} A_T^*$) exerted on the area increment between the physical and effective exit flow areas. The pressure, P_e' , is assumed to be equal to freestream pressure for nozzle pressure ratios less than critical (unity throat Mach number for one-dimensional flow). For nozzle pressure ratios greater than the choking pressure ratio (pressure ratio where the flow field is fixed and the discharge coefficient is independent of pressure ratio) P_e' is assumed equal to the exit pressure, P_e . A linear variation of P_e with nozzle pressure ratio is assumed between the critical and choking pressure ratios. The critical pressure ratio, $(P_{T_T}/P_\infty)_{CR}$, and choking pressure ratio, $(P_{T_T}/P_\infty)_{CK}$, are computed from the following equations.

$$(P_{T_T}/P_{\infty})_{CR} = \left(\frac{\gamma + 1}{2} \right)^{\gamma/(\gamma - 1)} \quad (19)$$

$$(P_{T_T}/P_{\infty})_{CK} = 3.5 - \tan \left\{ 23.8063 (C_{dN_{max}} - 0.95) \right\} \quad (20)$$

Equation 20 was empirically derived (Reference 41) and represents the nozzle pressure ratio at which the discharge coefficient, $C_{dN_{max}}$, remains fixed.

As discussed in Reference 41, the discharge coefficient, $C_{dN_{max}}$, is sensitive to both the upstream approach angle, α , and the nozzle lip radius of curvature, R_c . Correlations of the discharge coefficient ($C_{dN_{max}}$) as a function of approach angle and radius of curvature ratio, R_c/R_T , are presented in Figures 19 and 20 respectively. The appropriate discharge coefficient, $C_{dN_{max}}$, to be used in Equation 20 is the larger of the two values obtained from Figures 19 and 20.

The nozzle discharge coefficient obtained as described above is, of course, the appropriate discharge coefficient for nozzle pressure ratios greater than the choking pressure ratio (i.e., $C_{dN} = C_{dN_{max}}$). For nozzle pressure ratios less than the choking pressure ratio, the nozzle discharge coefficient, C_{dN} , is determined from the following equation:

$$C_{dN} = C_{dN_{max}} - C_2 \left\{ \frac{P_{T_T}}{P_{\infty}} - \left(\frac{P_{T_T}}{P_{\infty}} \right)_{CK} \right\}^2 + C_3 \left\{ \frac{P_{T_T}}{P_{\infty}} - \left(\frac{P_{T_T}}{P_{\infty}} \right)_{CK} \right\}^3 \quad (21)$$

where

$$C_2 = 8 B^3 / \left[(C_{dN_{max}} - 0.965)^2 + 4 B^2 \right] \quad (22)$$

and

$$C_3 = 0.0011 - 0.00205 \left[\sin (74.8 (C_{dN_{max}} - 0.952)) \right] + \left[(0.92 - C_{dN_{max}}) 0.0574 + \text{ABS} ((0.92 - C_{dN_{max}}) .0574) \right] / 2 \quad (23)$$

The constant, B , is set equal to 0.01. The above equations are empirically derived in Reference 41.

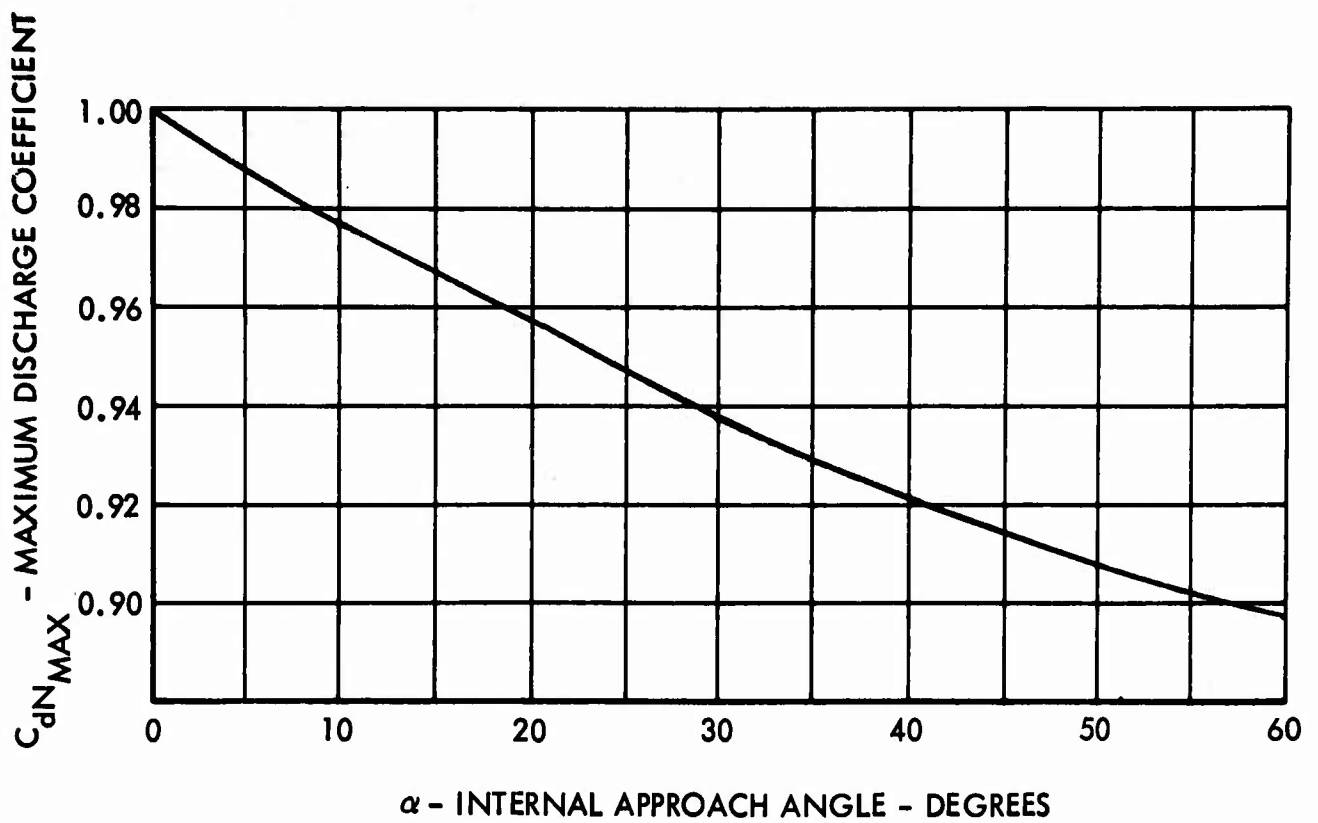


Figure 19. Correlation of Maximum Discharge Coefficient with Internal Approach Angle

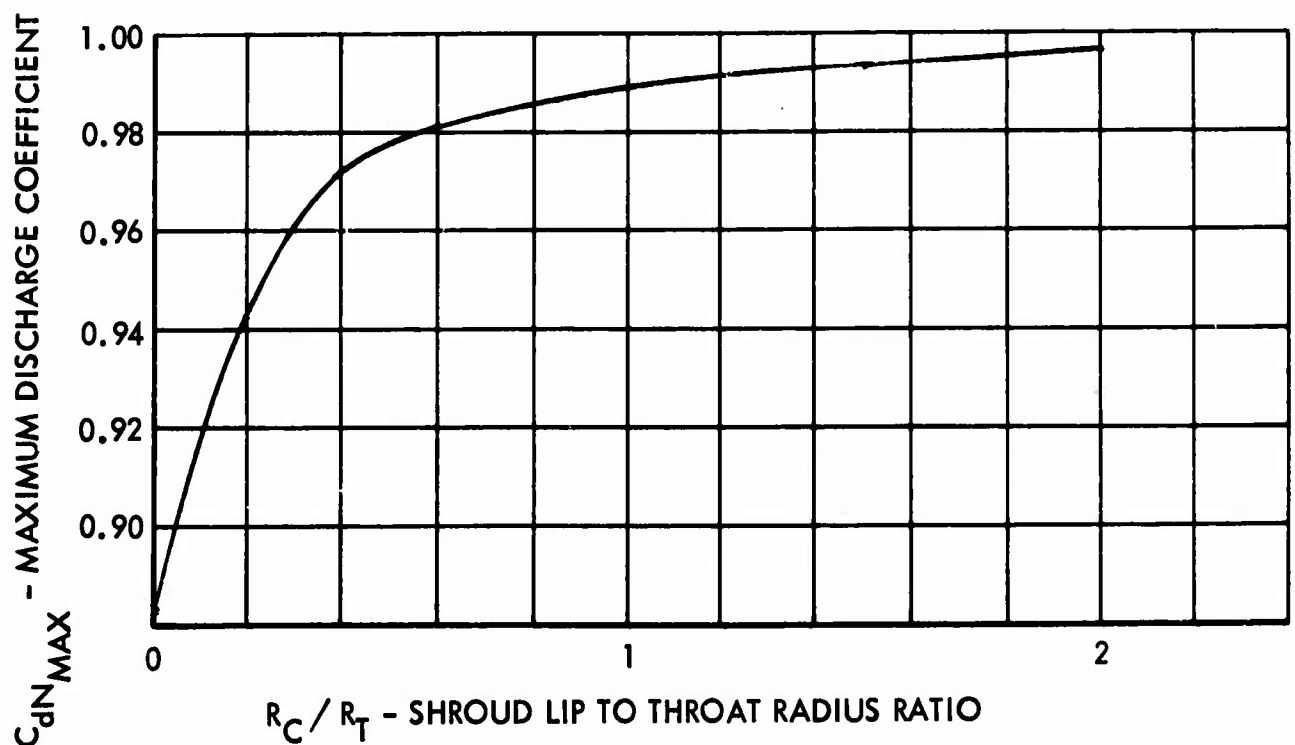


Figure 20. Correlation of Maximum Discharge Coefficient with Shroud Lip Curvature

The area ratios employed in the thrust coefficient equation (Equation 17) are obtained as follows. For nozzle pressure ratios less than critical, the ratio of actual to sonic flow areas ($A_{e_{flow}}/A_T^*$) is obtained in the usual manner from the exit Mach number, M_e . For nozzle pressure ratios greater than critical, the actual sonic flow area ratio is unity. The physical exit to sonic flow area ratio is obtained from the following equation for nozzle pressure ratios less than critical.

$$\frac{A_e}{A_T^*} = \frac{A_e}{A_{e_{flow}}} \frac{A_{e_{flow}}}{A_T^*} = \frac{1}{C_{dN}} \frac{A_{e_{flow}}}{A_T^*} \quad (24)$$

For nozzle pressure ratios greater than critical, the exit to sonic flow area ratio is equal to the inverse of the discharge coefficient.

3.2.2 Convergent-Divergent Nozzle

The method employed for computing convergent-divergent nozzle thrust coefficients depends upon whether the flow is unchoked, choked with internal flow separation, or choked and flowing full (i.e., no internal separation). For nozzle pressure ratios less than critical (unity throat Mach number for one-dimensional flow), the flow is subsonic and the nozzle is treated as a subsonic diffuser. The computational procedure is as follows. A throat Mach number is first assumed and a recovery loss coefficient $\Delta P_T/q_T$, is obtained from Figure 21 as a function of nozzle internal divergence angle, θ . The nozzle exit to throat total pressure ratio is obtained from the following equation.

$$\frac{P_{Te}}{P_{TT}} = \frac{q_T}{P_{TT}} \left(\frac{P_{TT}}{q_T} - \frac{\Delta P_{TT}}{q_T} \right) \quad (25)$$

The nozzle exit to sonic area ratio is then computed as

$$\frac{A_e}{A_e^*} = \frac{A_e}{A_T^*} \left(\frac{A_T^*}{A_e^*} \right) = \frac{A_e}{A_T^*} \left(\frac{P_{Te}}{P_{TT}} \right) \quad (26)$$

$$\frac{A_e}{A_T^*} = \frac{A_{T_{flow}}}{A_T^*} \left(\frac{A_T}{A_{T_{flow}}} \right) \left(\frac{A_e}{A_T} \right) \quad (27)$$

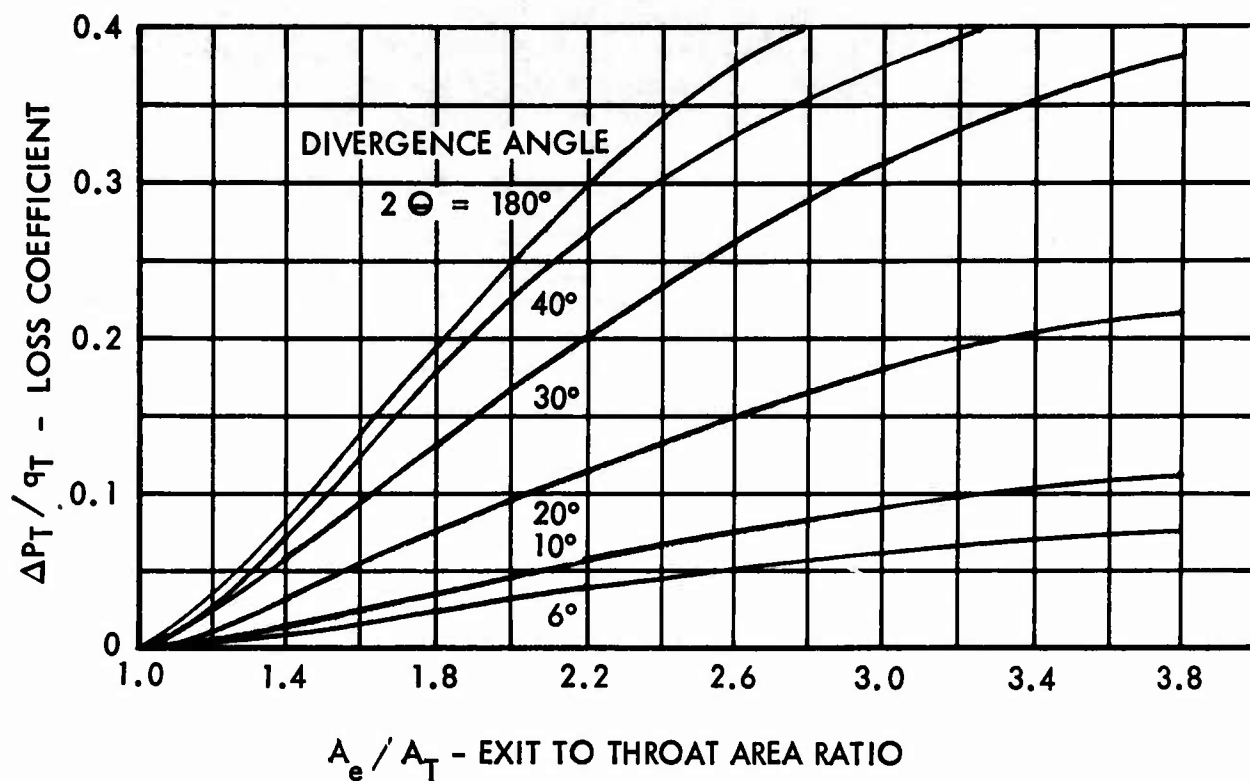


Figure 21. Correlation of Nozzle Internal Divergence Loss

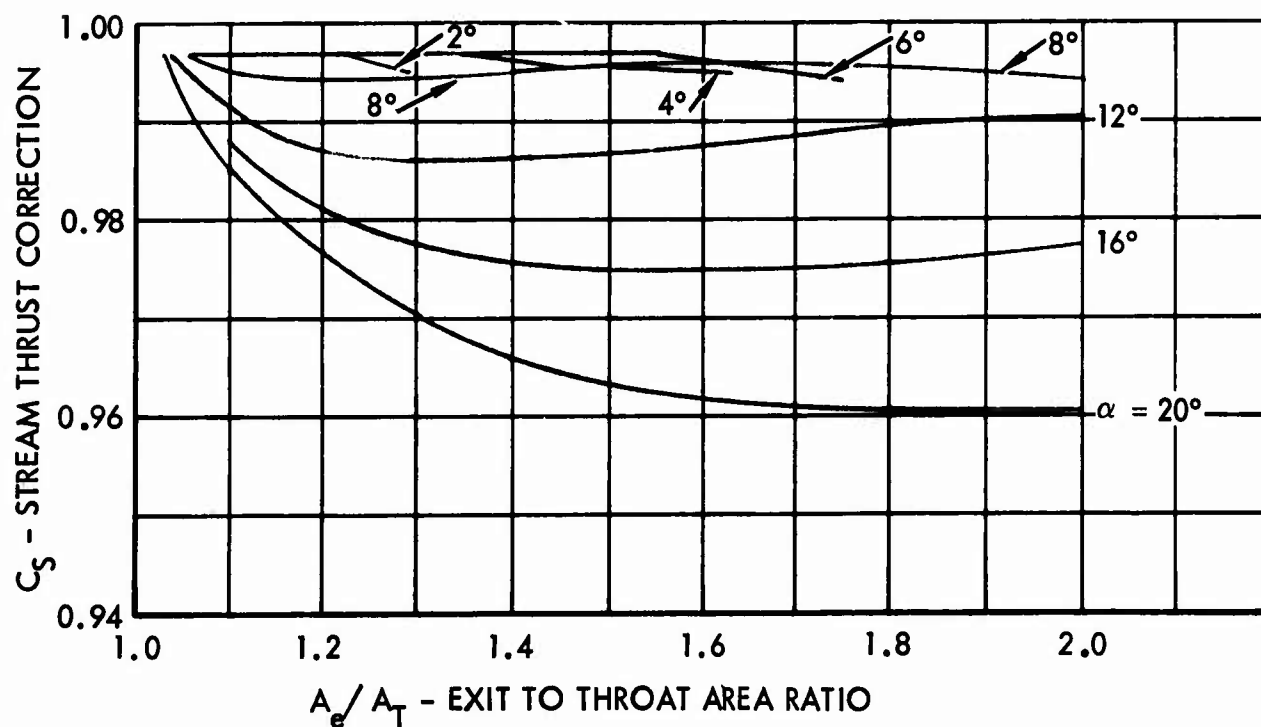


Figure 22. Correlation of Stream Thrust Correction Factor

The throat flow to sonic flow area ratio in Equation 27 is obtained as a function of the assumed throat Mach number and the throat flow to geometric throat area ratio is obtained from the nozzle discharge coefficient ($A_{T_{flow}}/A_T = C_{dN}$). The discharge coefficient is taken as the larger of the two values obtained from Figures 19 and 20. The exit to sonic area ratio obtained from Equation 26 yields an exit Mach number which in turn yields an exit static pressure. If the exit static pressure does not equal the freestream static pressure the calculations are repeated using a different value for the throat Mach number. The thrust coefficient is then computed from Equation 17 with A_e assumed equal to $A_{e_{flow}}$. The stream thrust correction factor is obtained from Figure 22 as a function of exit to sonic flow area ratio and internal divergence angle.

For nozzle pressure ratios greater than critical but less than that required for the nozzle to flow full (no separation), two computational procedures are employed. For nozzle pressure ratios slightly greater than critical, a linear variation of thrust coefficient from the critical value of thrust coefficient is assumed. This linear variation is terminated (based on empirical observation) at a nozzle pressure ratio computed from the following equation.

$$\left(\frac{P_{T_T}}{P_\infty}\right)_L = \left(\frac{P_{T_T}}{P_e}\right) \left(\frac{P_e}{P_\infty}\right) \quad (28)$$

where P_{T_T}/P_e is obtained (assuming the nozzle flows full) from one dimensional flow relationships and

$$\left(\frac{P_e}{P_\infty}\right)_L = 0.1 \left\{ 10^{0.0332\theta} + 0.72 \right\} \left[10 \left(\frac{A_e}{A_T} - 1 \right) \right]^{-0.77} \quad (29)$$

The thrust coefficient for nozzle pressure ratios greater than the computed pressure ratio from Equation 28, but less than that for the flowing full case, is computed from the following equation.

$$C_T = \frac{C_S \left[\frac{P_{sep}}{P_{T_T}} \frac{A_{e_{sep}}}{A_T^*} (1 + \gamma M_{sep}^2) \right] + \int \frac{P dA}{P_{T_T} A_T^*} - \frac{P_\infty A_e}{P_{T_T} A_T^*}}{F_{ip} / (P_{T_T} A_T^*)} \quad (30)$$

where P_{sep} is the static pressure just upstream of the separation point, $A_{e_{sep}}$ is the flow area at the separation point, M_{sep} is the Mach number at the separation point, and the integral term is the pressure force acting on the nozzle inner surface in the separated flow region. The stream thrust parameter, C_s , is obtained from Figure 22 as a function of A_{sep}/A_T^* and θ . The surface static (upstream of separation point) to total pressure ratio is computed from the following equation.

$$\frac{P_{sep}}{P_{T_T}} = 0.63 + 0.04 \ln (0.01) \frac{P_\infty}{P_{T_T}} \quad (31)$$

Equation 31 results determine the Mach number, M_{sep} , which in turn locates (through the area ratio function) the separation point. The integral term in Equation 30 is computed from the following empirical equation.

$$\int \frac{PdA}{P_{T_T} A_T^*} = \frac{P_\infty}{P_{T_T}} \left(\frac{6 + \frac{P_{sep}}{P_{T_T}} \frac{P_{T_T}}{P_\infty}}{7} \right) \left(\frac{A_e}{A_T^*} - \frac{A_{sep}}{A_T^*} \right) \quad (32)$$

When the nozzle is flowing full, Equation 17 is used for computing thrust coefficients. The exit flow area ($A_{e_{flow}}$) is, however, set equal to the physical area (A_e). The pressure ratio (P_{T_T}/P_∞) where the nozzle is just flowing full is computed from the following equation.

$$\left(\frac{P_{T_T}}{P_\infty} \right)_F = \frac{P_{sep}}{P_\infty} \left(\frac{P_{T_T}}{P_e} \right) \quad (33)$$

where P_{T_T}/P_e is obtained from a one-dimensional flowing full analysis and P_{sep}/P_∞ is a constant obtained from Equation 31 (after rearranging).

The nozzle discharge coefficient for convergent-divergent nozzles is defined as the ratio of actual mass flow to ideal convergent nozzle mass flow, or

$$C_{d_N} = \frac{(\dot{m}_{C-D})_{act}}{(\dot{m}_{CONV})_{id}} \quad (34)$$

In terms of ideal conditions, the above equation becomes

$$C_{d_N} = \frac{(\dot{m}_{C-D})_{id}}{(\dot{m}_{CONV})_{id}} \frac{A_{T \text{ flow}}}{A_T} \quad (35)$$

where $A_{T \text{ flow}}/A_T$ is the larger of the two values obtained from Figures 19 and 20. For pressure ratios greater than critical for the reference convergent nozzle, the ideal mass flow for the C-D nozzle is identical to the ideal mass flow of the convergent nozzle. Thus, the discharge coefficients can be obtained, as previously described, from Figures 19 and 20. For pressure ratios less than critical for the reference convergent nozzle, the ideal C-D nozzle mass flow is greater than the ideal convergent nozzle mass flow. This is because the critical pressure ratio for a C-D nozzle is lower than the critical pressure ratio for a convergent nozzle due to the diffusion in the divergent section. The discharge coefficient equation is rewritten, therefore, as

$$C_{d_N} = \frac{M_T \left(1 + \frac{\gamma-1}{2} M_T^2\right)^{-\left(\frac{\gamma+1}{2(\gamma-1)}\right)} A_{T \text{ flow}}}{M_e \left(1 + \frac{\gamma-1}{2} M_e^2\right)^{-\left(\frac{\gamma+1}{2(\gamma-1)}\right)} A_T} \quad (36)$$

where M_T is the C-D nozzle throat Mach number and M_e is the exit Mach number of the reference convergent nozzle.

3.2.3 Convergent-Divergent Ejector Nozzle

The computational method employed for predicting C-D ejector nozzle performance follows closely the method employed for C-D nozzles. The primary difference is the addition of a routine for computing the ejector pumping characteristics. The method employed is the one-dimensional compound-compressible flow analysis of Bernstein (Reference 45). Bernstein's method is programmed so as to obtain secondary to primary mass flow ratio as a function of secondary to primary total pressure ratio and vice versa.

With the addition of the nozzle secondary flow, the nozzle thrust coefficient equation with no internal flow separation becomes

$$C_T = \frac{C_S \left[\frac{P_e}{P_{TP}} \frac{A_{eP}}{A_{TP}^*} (1 + \gamma M_{eP}^2) + \frac{P_e}{P_{TP}} \frac{A_{eS}}{A_{TP}^*} (1 + \gamma M_{eS}^2) \right] - \frac{P_\infty A_e}{P_{TP} A_{TP}^*}}{\left(\frac{F_{id}}{P_{TP} A_{TP}^*} \right)_P + \left(\frac{F_{id}}{P_{TP} A_{TP}^*} \right)_S} \quad (37)$$

where the secondary and primary flow areas, Mach numbers, and exit pressure at the nozzle exit are obtained from standard one-dimensional calculations employing the secondary to primary mass flow ratios and total pressure ratios. The stream thrust correction factor, C_s , is obtained from Figure 22 as a function of internal divergence angle and shroud exit to primary nozzle area ratio. For cases with internal flow separation, the thrust coefficients are computed by a method similar to that employed for C-D nozzles. Primary nozzle discharge coefficients are also computed in the same manner as for C-D nozzles.

3.2.4 Plug Nozzles

The plug nozzle performance routine is based on both analytical and empirical correlation methods. Specifically, for supersonic flight Mach numbers a combined analytical/empirical method is employed, while an empirical method is employed for subsonic flight Mach numbers. The reason for this is that, for supersonic flight Mach numbers, the nozzle pressure ratio is sufficiently high such that there is little or no influence of the external flow on the plug surface pressure distributions. For subsonic flight Mach numbers, the influence of the external flow is felt over a large portion of the plug surface, especially at low nozzle pressure ratios.

The method employed for computing the plug surface pressure force and nozzle thrust coefficient for a supersonic external flow is as follows. First, the total flow expansion around the shroud lip is computed assuming the flow expands to freestream static pressure. This flow turning is divided into a number of equal turning increments. For the initial flow angle increment, the Mach number at the shroud lip is computed using the Prandtl-Meyer relationship. The right running characteristic ray is then constructed and its intersection with the plug surface computed. For this computation, the characteristic ray is assumed to be straight. The plug surface Mach number at the intersection point is obtained from the Prandtl-Meyer relationship assuming a flow deflection equal to twice the flow turning increment at the shroud lip. This procedure accounts, approximately, for the expansion fan reflection from the plug surface. The method is approximate, since the actual characteristic ray is curved rather than straight, as assumed. Nonetheless the surface pressure distributions computed as described are in excellent agreement with exact method-of-characteristic calculations.

The above procedure is repeated until the flow is expanded to freestream pressure or the end of the plug is reached. In the former case, where the last ray intersects the surface upstream of the plug base, the external flow will definitely influence the plug surface pressure distributions. It is assumed, however, that the region influenced by the external flow is small. It is further assumed that the pressures in this region are near freestream pressure. Based on empirical observations, the above assumptions will introduce little error provided the nozzle pressure ratio is greater than approximately 4.0 and the plug configuration is similar to those tested.

The nozzle gross thrust is the sum of the gross thrust at the nozzle exit, the plug surface pressure force, and the plug base force (or drag). The gross thrust at the nozzle exit for unshrouded nozzles is computed in the same manner as for convergent nozzles and for shrouded plug nozzles in the same manner as for C-D nozzles. Plug base pressure correlations are employed for computing plug base forces. The plug base pressure is computed from the following correlation equation:

$$\frac{P_b}{P_{T_T}} = \frac{4.312}{(P_{T_T}/P_\infty)^{1.975}} \quad (38)$$

This equation is applicable for nozzle pressure ratios ranging from approximately 4.5 to the pressure ratio where the ratio of base pressure to nozzle total pressure remains invariant with nozzle pressure ratio. The plug base to nozzle total pressure ratio becomes invariant with pressure ratio when the last characteristic ray from the shroud lip lies downstream of the base wake region.

The invariant base pressure is computed from the following equation:

$$\frac{P_b}{P_{T_T}} = 0.517 \left(\frac{P_P}{P_{T_T}} \right)_e + 0.0046 \quad (39)$$

where $(P_P/P_{T_T})_e$ is the ratio of plug surface static pressure just upstream of the plug base to nozzle total pressure. For nozzle pressure ratios less than 4.5, the base pressure is assumed equal to freestream static pressure.

For a subsonic external flow, the plug nozzle thrust coefficient is computed from the following equation:

$$C_T = C_{T_e} + \frac{\Delta D}{F_{id}} - K_{l_4} \quad (40)$$

where

$$K_{l_4} = \frac{\Delta D}{F_{id}} - (C_T - C_{T_e}) \quad (41)$$

C_{T_e} in the above equation is the ratio of computed gross thrust at the nozzle exit to ideal gross thrust (F_{id}) obtained by expanding the flow isentropically to freestream static pressure, and ΔD is the drag increment between operation at the design pressure ratio and operation at a higher pressure ratio and is obtained from Figures 14 and 15 as a function of the underexpansion loss, $(1 - C_{T_e})$. The plug thrust/drag parameter, K_{l_4} , is obtained through interpolation and extrapolation of the correlation results presented in Figures 23 and 24.

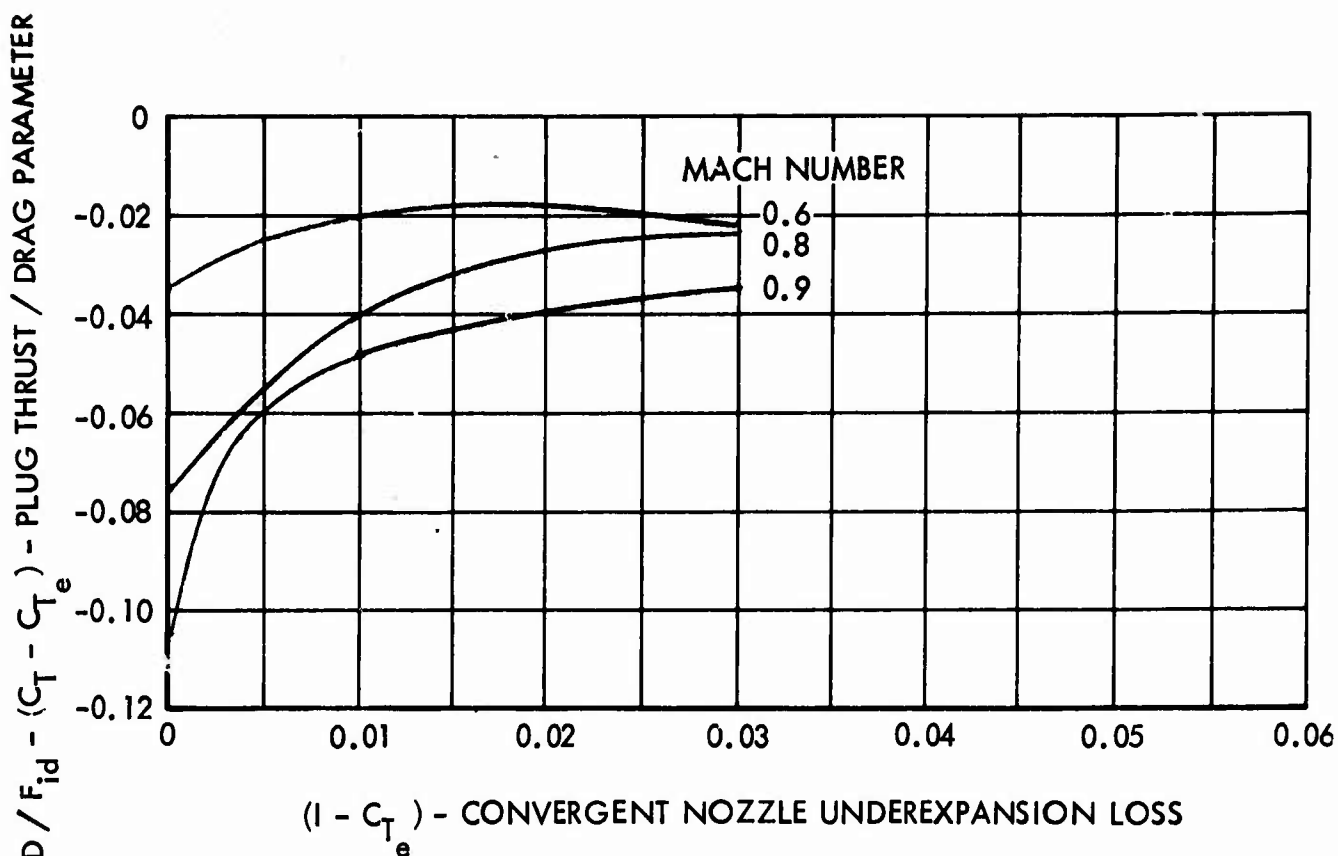


Figure 23. Correlation of Plug Thrust and Boattail Drag Increment - Normal Power Plug Nozzle

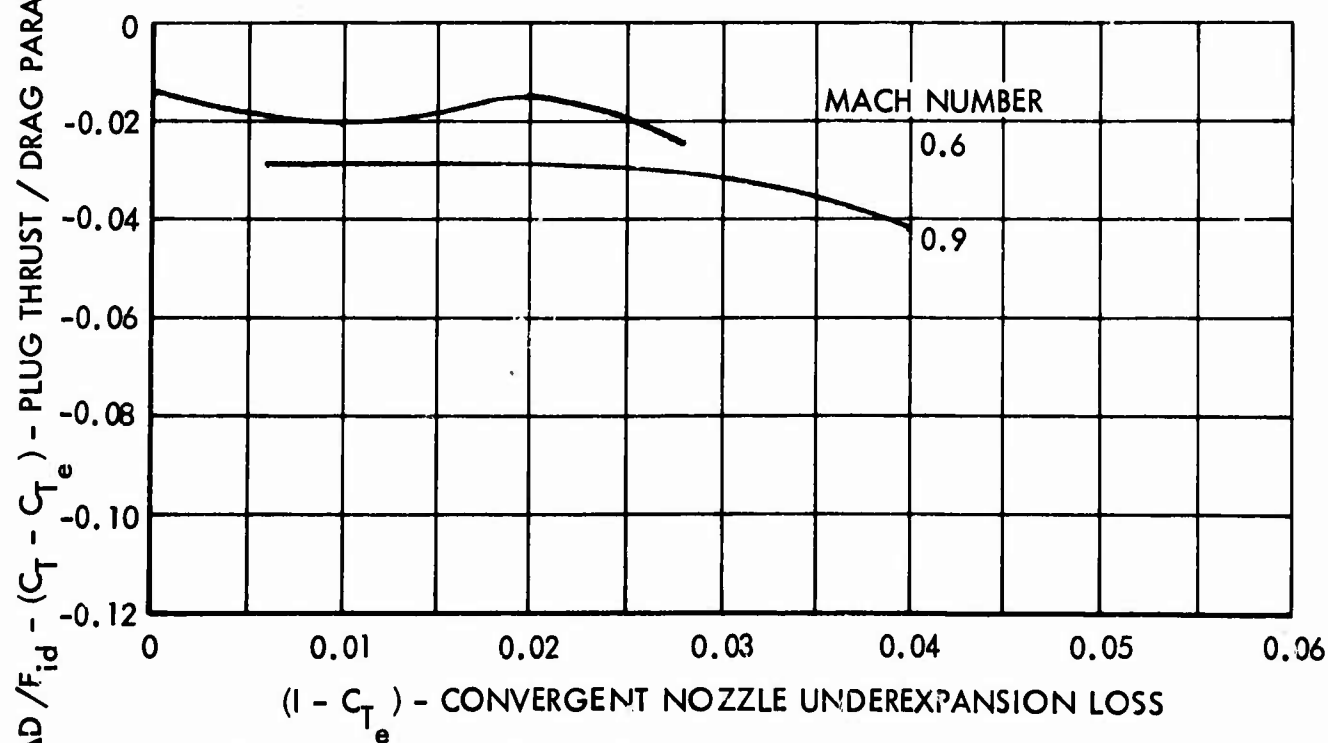


Figure 24. Correlation of Plug Thrust and Boattail Drag Increment - Maximum A/B Power Plug Nozzle

SECTION 4

OPERATING INSTRUCTIONS

4.1 INPUT REQUIREMENTS

The input for the external drag and internal nozzle performance computer program consists of fixed and variable parameters in a main 25 card set plus optional curve data and input routine control cards. The fixed inputs, which are constants for each computer run, are discussed in Subsection 4.1.1. The variable inputs, which allow a series of values or curve data to be input for each run, are discussed in Subsection 4.1.2, followed by a description of the required input control cards in Subsection 4.1.3. The 25 card main input data set is summarized in Table 1, including card numbers, data descriptions and locations, available input options, and where appropriate, identifiers for the optional curve data inputs. Tables 2 and 3 describe the input curve formats. Sample input sheets are given in Appendix A.

4.1.1 Fixed Input

The fixed input data required are the title, the basic aircraft external geometric data, and the nozzle internal geometry data. The title, on card 1, may consist of any combination of alpha-numeric characters and may be placed anywhere in columns 1 through 72. This title will be printed at the top of each page of computer printout. The first three inputs on card 2 are input keys for selection of nozzle spacing, nozzle type, and interfairing type, and have the options shown in Table 1. The inputs are integers (no decimal) input in fields of 3 columns starting with column 1. The integer inputs must be right-adjusted; i.e., the final digit must fall in the last column of the input field. The last six inputs on card 2 are real numbers (input with decimals) in fields of six columns starting with column 10. These inputs include wing area, maximum cross-sectional area, ratio of metric break area to maximum area, the initial boattail length, initial boattail integral mean slope (IMSF), and boattail wetted area for the portion of the aftbody between the maximum area location and the metric break.

Nozzle internal fixed inputs are shown in Table 1 under each nozzle type heading. The nozzle fixed inputs are on the last non-blank card in the data set; however, enough blank cards must be added at the end of the set to make a total of 25 cards. The inputs required for convergent nozzles are the minimum and maximum throat areas corresponding to normal and max A/B power settings, input as real numbers on the first two fields of 6 on card 22. For convergent-divergent nozzles, the axial length of the nozzle divergent section, the minimum nozzle expansion ratio, and the maximum nozzle expansion ratio are input as real numbers on card 22 in fields of 6 columns, starting with column 1. The fixed inputs for the convergent-divergent ejector nozzle

TABLE 1. MAIN DATA SET INPUT KEY

CARD	QUANTITY	TYPE	MODE	COLUMNS	INPUT OPTIONS	
					CODE	DESCRIPTION
1	Title	Fixed	Alpha-numeric	1 - 72		Title or identification of case to be printed at top of print-out
2	Nozzle Spacing Ratio, S/D	Fixed	Integer	1 - 3	1	Narrow ($S/D \approx 1.25$) single vertical
					2	Intermediate ($S/D \approx 1.625$) single vertical
					3	Wide ($S/D \approx 2.0$) single vertical
					4	Wide with twin vertical
	Nozzle Type, NT	Fixed	Integer	4 - 6	1	Convergent
					2	Convergent-Divergent
					3	Convergent-Divergent Ejector
					4	Unshrouded Plug
					5	Shrouded Plug
					1	Horizontal
					2	Vertical
	Wing Area, A_{Wing}	Fixed	Real	10 - 15		Reference Area, ft^2
						Aircraft maximum area excluding lifting portion of wing -- ft^2
						Fuselage area at wing trailing edge station, $A_{\text{MB}}/A_{\text{M}} \approx 0.85$
						Axial distance between A_{M} and A_{MB} stations
	Interfacing Type, IT	Fixed	Integer	7 - 9		
	Wing Area, A_{Wing}	Fixed	Real	10 - 15		
	Maximum Area, A_{M}	Fixed	Real	16 - 21		
	Metric Break Area Ratio, $A_{\text{MB}}/A_{\text{M}}$	Fixed	Real	22 - 27		
	Initial Boattail Length to Maximum Diameter Ratio, $L_{\text{MB}}/D_{\text{M}}$	Fixed	Real	28 - 33		

TABLE 1. MAIN DATA SET INPUT KEY (Continued)

CARD	QUANTITY	TYPE	MODE	COLUMNS	I N P U T O P T I O N S	
					CODE	DESCRIPTION
3	IMSF	Fixed	Real	34 - 39		IMS for initial boattail surface. Enter -1. for curve ($X = X/D_M$, $Y = A/A_M$, $Z = 0$) IDC020
	Initial Boattail Wetted Area Ratio A_{WF}/A_M	Fixed	Real	40 - 45		Wetted area for initial boattail surface
	Flight Speed	Vari- able	Mixed*	46 - 72		Blank
4	Freestream Pressure	Vari- able	Mixed		1	Freestream Mach number
					2	True air speed - knots
					3	True air speed - mph
					4	Indicated air speed - knots
					5	Indicated air speed - mph
5	Freestream Temperature	Vari- able	Mixed		1	Ambient pressure, psf
					2	Geometric altitude, ft.
					3	Geopotential altitude, ft.
					4	Reynolds number per foot, millions
6	Nozzle Power Setting, PS	Vari- able	Mixed		1	Ambient temperature, °R
					2	Non-standard temperature increment, °R
					3	Total temperature, °R
7	Nozzle Pressure Ratio, P_{Tp}/P_∞	Vari- able	Mixed		1	Clean wind tunnel model
					2	Actual aircraft model
					1	Input P_{Tp}/P_∞
					2	Curve ($X=M_\infty$, $Y=P_{Tp}/P_\infty$, $Z=0$) IDC072
					3	Curve ($X=M_\infty$, $Y=P_{Tp}/P_\infty$, $Z=PS$) IDC073

TABLE 1. MAIN DATA SET INPUT KEY (Continued)

CARD	QUANTITY	TYPE	MODE	COLUMNS	INPUT OPTIONS	
					CODE	DESCRIPTION
8	Nozzle Specific Heat Ratio, γ_p	Variable	Mixed		1	Input γ_p
					2	Curve ($X=PS$, $Y=\gamma_p$, $Z=0$) IDC082
9	Nozzle Throat Area	Variable	Mixed		1	Input physical area, A_T -- ft^2
					2	Curve ($X=M_{co}$, $Y=A_T$, $Z=0$) IDC092
					3	Input flow area, A_{Tflow} -- ft^2
					4	Curve ($X=M_{co}$, $Y=A_{Tflow}$, $Z=0$) IDC094
10	Nozzle Throat Approach Angle, α	Variable	Mixed		1	Input α , degrees
					2	Curve ($X=A_T$, $Y=\alpha$, $Z=0$) IDC102
11	Nozzle Throat Geometry	Variable	Mixed		1	Input R_c/R_T if $NT < 4$
						Input $R_c R_T / S^2$ if $NT \geq 4$
					2	Curve ($X=A_T$, $Y=R_c/R_T$ or $R_c R_T / S^2$, $Z=0$) IDC112
12	Nozzle Expansion Ratio, A_E/A_T	Variable	Mixed		1	$A_E/A_T = 1.0$ (convergent & Unshrouded plug nozzles)
					2	Input A_E/A_T , exit to throat area ratio
					3	Curve ($X=A_T$, $Y=A_E/A_T$, $Z=0$) IDC123
					4	Maximum thrust minus drag

TABLE 1. MAIN DATA SET INPUT KEY (Continued)

CARD	QUANTITY	TYPE	MODE	COLUMNS	INPUT OPTIONS	
					CODE	DESCRIPTION
13	Nozzle Annular Base Area Ratio, A_B/A_E	Variable	Mixed		1 2	Input A_B/A_E , base to exit area ratio Curve ($X=A_E$, $Y=A_B/A_E$, $Z=0$) IDC132
14	Nozzle Base Length to Diameter Ratio, $\Delta X/D_M$	Variable	Mixed		1 2	Input $\Delta X/D_M$ Curve ($X=A_E$, $Y=\Delta X/D_M$, $Z=0$) IDC142
15	Nozzle Boattail Trailing Edge Angle, θ_E	Variable	Mixed		1 2	Input θ_E , degrees Curve ($X=A_E$, $Y=\theta_E$, $Z=0$) IDC152
16	Mean Nozzle Boattail Trailing Edge Angle, θ_M	Variable	Mixed		1 2	Input θ_M , degrees Curve ($X=A_E$, $Y=\theta_M$, $Z=0$) IDC162
17	Total Boattail Length to Diameter Ratio, L/D_M	Variable	Mixed		1 2	Input L/D_M Curve ($X=A_M-A_F$, $Y=L/D_M$, $Z=0$) IDC172
18	IMS for Surface Aft of Metric Break Station, IMSA	Variable	Mixed		1 2 3	Input IMSA Curve ($X=A_M-A_F$, $Y=IMSA$, $Z=0$) IDC182 Curve ($X=X/D_M$, $Y=A/A_M$, $Z=0$) IDC183

TABLE 1. MAIN DATA SET INPUT KEY (Continued)

INPUT OPTIONS						
CARD	QUANTITY	TYPE	MODE	COLUMNS	CODE	DESCRIPTION
19	Adjusted Projected Frontal Area Ratio, $\Delta A/A_M$	Variable	Mixed		1	Input $\Delta A/A_M$
					2	Curve ($X=A_M-A_F$, $Y=\Delta A/A_M$, $Z=0$) IDC192
20	Boundary Layer Momentum Thickness Ratio, δ^*/D_M	Variable	Mixed		1	Input θ/D_M
					2	Curve ($X=M_\infty$, $Y=\theta/D_M$, $Z=0$) IDC202
					3	Curve ($X=M_\infty$, $Y=\theta/D_M$, $Z=R_E/ft.$) IDC203
					4	Input effective flat plate length to maximum diameter ratio instead of θ/D_M
21	Total Boattail Wetted Area Ratio, A_W/A_M	Variable	Mixed		1	Input A_W/A_M
					2	Curve ($X=A_E$, $Y=A_W/A_M$, $Z=0$) IDC212
<u>CONVERGENT NOZZLE</u>						
22	Minimum Nozzle Throat Area, $A_{T_{MIN}}$	Fixed	Real	1 - 6		Normal power throat area
23-25	Maximum Nozzle Throat Area, $A_{T_{MAX}}$	Fixed	Real	7 - 12		Max A/B throat area
				13 - 72		Blank
				1 - 72		Blank

TABLE 1. MAIN DATA SET INPUT KEY (Continued)

CARD	QUANTITY	TYPE	MODE	COLUMNS	I N P U T O P T I O N S	
					CODE	DESCRIPTION
CONVERGENT-DIVERGENT NOZZLE						
22	Length of Internal Expansion Surface, FL	Fixed	Real	1 - 6		Surface length between A_T and A_E stations, ft.
	Minimum Nozzle Expansion Ratio, $(A_E/A_T)_{MIN}$	Fixed	Real	7 - 12		Minimum physical exit to throat area ratio
	Maximum Nozzle Expansion Ratio $(A_E/A_T)_{MAX}$	Fixed	Real	13 - 18		Maximum physical exit to throat area ratio
23-25				19 - 72		Blank
				1 - 72		Blank
CONVERGENT-DIVERGENT EJECTOR NOZZLE						
22	Shroud Throat Area Ratio, A_{ST}/A_T	Variable	Mixed		1	Input A_{ST}/A_T
					2	Curve ($X=A_T$, $Y=A_{ST}/A_T$, $Z=0$) IDC222
23	Pumping Characteristics	Variable	Mixed		1	Input P_{TS}/P_{TP}
					2	Curve ($X=M_\infty$, $Y=P_{TS}/P_{TP}$, $Z=0$) IDC232
					3	Input Corrected W_S/W_P
					4	Curve ($X=M_\infty$, $Y=Corrected\ W_S/W_P$, $Z=0$) IDC234

TABLE 1. MAIN DATA SET INPUT KEY (Continued)

CARD	QUANTITY	TYPE	MODE	COLUMNS	INPUT DESCRIPTION	
					CODE	DESCRIPTION
24	Secondary to Primary Gas Constant Ratio, R_S/R_P	Variable	Mixed		1	Input R_S/R_P
					2	Curve ($X=PS$, $Y=R_S/R_P$, $Z=0$) IDC242
25	Length of Internal Expansion Surface, FL	Fixed	Real	1 - 6		Surface length between A_{ST} and A_E stations, ft.
	Minimum Nozzle Expansion Ratio, (A_E/A_T) Min	Fixed	Real	7 - 12		Minimum physical exit to throat area ratio
	Maximum Nozzle Expansion Ratio, (A_E/A_T) Max	Fixed	Real	13 - 18		Maximum physical exit to throat area ratio
	Secondary Flow Specific Heat Ratio, γ_S	Fixed	Real	19 - 24		Secondary air usually obtained from inlet, $\gamma_S = 1.4$
				25 - 72		Blank
PLUG NOZZLES						
22	Plug Length to Diameter Ratio, L_P/D_M	Variable	Mixed		1	Input L_P/D_M
					2	Curve ($X=A_T$, $Y=L_P/D_M$, $Z=0$) IDC222
23	Plug Angle, α_P	Fixed	Real	1 - 6		Conical plug angle, degrees
	Plug Base Area, A_{Pb}	Fixed	Real	7 - 12		Truncated plug base area, ft^2

TABLE 1. MAIN DATA SET INPUT KEY (Continued)

CARD	QUANTITY	TYPE	MODE	COLUMNS	CODE	INPUT OPTIONS	
						DESCRIPTION	
24-25	Minimum Nozzle Throat Area, A_{TMin}	Fixed	Real	13 - 18		Normal power throat area	
	Maximum Nozzle Throat Area, A_{TMax}	Fixed	Real	19 - 24		Max A/B throat area	
	Minimum Nozzle Expansion Ratio, $(A_E/A_T) Min$	Fixed	Real	25 - 30		Minimum physical exit to throat area ratio	
	Maximum Nozzle Expansion Ratio, $(A_E/A_T) Max$	Fixed	Real	31 - 36		Maximum physical exit to throat area ratio	
				37 - 72		Blank	
				1 - 72		Blank	

* Format for the mixed mode variable input cards is:

Columns	Quantity	Mode
1 - 3	Card number	Integer
4 - 6	Number of input values	Integer
7 - 9	Input code	Integer
10 - 69	10 fields of 6 columns for input data	Real

TABLE 2. UNIVARIANT CURVE DATA INPUT KEY

CARD	COLUMNS	MODE	CODE	DESCRIPTION
1	1-6	Alpha-Numeric	--	Curve identifier
	7-9	Integer	1	Linear interpolation
			2	Parabolic interpolation
	10-12	Integer	0	No extrapolation on X
			1	Extrapolation on X
	13-15	Integer	--	Number of X and Y numbers
2	1-72	Real	--	Data in order X, Y, X, Y, . . . in fields of six columns each. May require several cards

TABLE 3. BIVARIANT CURVE DATA INPUT KEY

CARD	COLUMNS	MODE	CODE	DESCRIPTION
1	1-6	Alpha-Numeric	--	Curve identifier
	7-9	Integer	3	Linear interpolation on both X and Z
			4	Parabolic interpolation on both X and Z
			5	Parabolic interpolation on X and linear on Z
	10-12	Integer	-1	Extrapolation on X only
			0	No extrapolation
			1	Extrapolation on both X and Z
	13-15	Integer	--	Number of Z values to be read (may be up to 19)
	16-72	Integer	--	Number of X and Y numbers for each Z, in order of input, in fields of 3 columns each
2	1-72	Real	--	Data in order Z, X, Y, X, Y, . . . , Z, X, Y, . . . in fields of six columns each. May require several cards.

are on card 25 and are the same as for the convergent-divergent nozzle except for the addition of the secondary flow specific heat ratio (real number) in columns 19 through 24. The plug nozzle fixed inputs, real numbers in the first six fields of 6 columns on card 23, are the conical plug angle, the plug base area, the minimum throat area, the maximum throat area, the minimum nozzle expansion ratio, and the maximum nozzle expansion ratio.

The following nomenclature is employed for the fixed input terms in Table 1. Self explanatory items are not included.

- S/D - Nozzle Spacing Ratio - The ratio of the distance between the centerlines of the nozzles to the maximum nozzle diameter. The approximate values of 1.25 for narrow, 1.625 for intermediate, and 2.0 for wide spaced nozzles are suggested since the data correlations are based on data for these ratios.

- NT - Nozzle Type - Convergent type nozzles include convergent-flap and convergent-iris types.

- IT - Interfairing Type - The distinguishing characteristics of the interfairings is the orientation of the trailing edge (vertical or horizontal).

- A_{MB}/A_M - Metric Break Area Ratio - The approximate value of 0.85 is suggested since the data correlations were obtained with this value.

- IMSF - Forward Integral Mean Slope - IMS value for the surface between the maximum fuselage area and the metric break stations. A negative input means that an area distribution curve (X/D_M vs A/A_M) is being included and IMSF will be computed internally.

- A_{WF}/A_M - Initial Boattail Wetted Area Ratio - The wetted area (not including the lifting portion of the wing) from the maximum fuselage area station to the metric break station, divided by the maximum area.

- $(A_E/A_T)_{MIN}$ - Minimum Nozzle Expansion Ratio - The minimum expansion ratio used to test for maximum thrust-minus-drag.

- $(A_E/A_T)_{MAX}$ - Maximum Nozzle Expansion Ratio - The maximum expansion ratio used to test for maximum thrust-minus-drag. Twenty expansion ratio values are tested between the minimum and maximum values.

4.1.2 Variable Inputs

The variable inputs are those data which are changed as parameters of the performance analysis plus the portions of the aircraft internal and external geometry which change with variations of these parameters. Each type of variable input occurs on a different card, allowing the user to input several

values of each run parameter on each card. The program runs all possible combinations of the run parameters, cycling from larger to smaller sequence card numbers and from left to right for a given sequence number.

The input cards for the variable input data, cards 3 through 21 plus nozzle type dependent cards, all have the same data format. The first three fields on each card are of 3 columns each, starting with column 1. These three inputs are integers and include, in order, a sequence or identification number which is the same as the card number, the number of values of the variable input which appear on the card, and an input code selecting from the possible input types allowed for each variable input, as noted in Table 1. All the integer inputs must be right-adjusted in their respective fields. Up to ten values of each parameter may be input on each card in the following ten real number fields of six columns each, columns 10 through 69.

The following input code (ICODE) combinations for input of the freestream conditions in cards 3, 4 and 5 are unacceptable.

<u>ICODE (3)</u>	<u>ICODE (4)</u>	<u>ICODE (5)</u>
1	1	2
1	4	2
≥ 2	1	2
≥ 2	1	3
≥ 2	4	1
≥ 2	4	2
≥ 2	4	3

If any of these ICODE combinations are used, an error message will result with a brief description of the inconsistency.

The following nomenclature is employed for the variable input items in Table 1.

- PS - Power Setting - The value of power setting is used only as an independent variable on optional user-supplied curves (see cards 7, 8, and CD ejector card 24). The scheme of the power setting values is left up to the user.
- P_{T_P}/P_∞ - Nozzle Pressure Ratio - Primary total to freestream pressure ratio in the case of an ejector nozzle.
- γ_P - Nozzle Specific Heat Ratio - Primary stream specific heat ratio in the case of an ejector nozzle.

Nozzle Throat Area - Either the physical throat area (A_T) or the aerodynamic throat area ($A_{T_{flow}}$) may be input. Whichever is input, the program will compute the other internally.

- α - Nozzle Throat Approach Angle - The angle between the internal wall and the nozzle centerline in the conical part (if any) upstream of the nozzle (primary) throat. For plug nozzles, enter zero.

Nozzle Throat Geometry - For convergent, convergent-divergent, and convergent-divergent ejector nozzles, the ratio of the internal contour radius of curvature (if any) at the nozzle (primary) throat to the throat radius (R_C/R_T). For plug nozzles, the input value is $R_C R_T/S^2$, where R_C is the average radius of curvature between the internal shroud and plug at the throat, R_T is the average radius between the shroud and the plug at the throat, measured from the nozzle centerline, and S is the height of the throat region measured normal to the plug.

- A_E/A_T - Nozzle Expansion Ratio - A value not equal to 1.0 for the case of a convergent or unshrouded plug nozzle will result in an error message. A request for the maximum thrust-minus-drag will perturb the expansion ratio from the minimum to the maximum value.
- $\Delta X/D_M$ - Nozzle Base Length to Diameter Ratio - The axial distance covered by the base of a nozzle, such as in the case of a flap nozzle, divided by the equivalent maximum diameter.
- θ_M - Mean Nozzle Boattail Trailing Edge Angle - The mean boattail angle at the end of the boattail over a distance of one-third the exit radius.
- L/D_M - Total Boattail Length to Diameter Ratio - The total length from the maximum area station to the end of the nozzle or interfairing, whichever extends further, divided by the equivalent maximum diameter. The independent variable in the curve IDC172 is the difference between the maximum and total frontal areas, equivalent to the base plus exit areas.
- IMSA - Aft Integral Mean Slope - A code equal to 3 means an area distribution curve is being furnished consisting of X/D_M versus A/A_M aft of the metric break in order to calculate IMAS internally. The initial area (metric break area) must be the maximum area of the array and the areas must be continually decreasing with increasing X .
- $\Delta A/A_M$ - Adjusted Projected Frontal Area Ratio - An non-zero input is used when the configuration is characterized by an increase in area distribution, such as in the case of the fantail portion of a maximum afterburning nozzle. The value of ΔA is that frontal area, forward and rearward facing, which is not included in the frontal area determined by taking the maximum minus the exit plus base areas.
- θ_E - Nozzle Boattail Trailing Edge Angle - The nozzle boattail angle at the trailing edge of the boattail surface.

A_W/A_M - Total Boattail Wetted Area Ratio - The wetted area (not including the control surfaces) from the maximum area station to the end of the body.

A_{ST}/A_T - Shroud Throat Area Ratio - The ratio of the minimum area of the mixed region of an ejector nozzle to the primary throat area.

Pumping Characteristics - User has the option of furnishing either the secondary to primary total pressure ratio, P_{TS}/P_{TP} , or the corrected mass flow ratio, $W_s\sqrt{T_{Ts}} / W_p\sqrt{T_{Tp}}$.

L_P/D_M - Plug Length to Diameter Ratio - The length of the exposed portion of the plug divided by the equivalent maximum diameter of the configuration.

Most of the variable inputs may be input as curves as an allowable option. To exercise this option, the user places a 1 in column 6 (number of input values) and the appropriate input code in column 9. The data curves are then input as either univariant (one independent and one dependent variable) or bi-variant (one dependent and two independent variables) according to the input code selected. The identifier (name) of each curve (as given in Table 1) is formed by adding the (two-digit) card number and (one-digit) input code number to the characters IDC. For instance, a bivariant curve for nozzle pressure ratio is called IDC073. The curve data are input on cards following the 25 cards in the main input set.

Univariant curve data must begin with a card containing the curve identifier (alpha-numeric) in columns 1 through 6, an interpolation code integer in columns 7 through 9, an extrapolation code integer in columns 10 through 12, and the total number (integer) of input fields for X and Y data for the curve in columns 13 through 15. The succeeding cards contain the data in the order $X_1, Y_1, X_2, Y_2, \dots$ in real number (decimal) fields of six columns each starting in column 1. The univariant curve data input key is found in Table 2.

Bivariant curve data begin with a card containing the identifier (columns 1 through 6), the interpolation code in columns 7 through 9, the extrapolation code in columns 10 through 12, the number of Z values (integer, columns 13 through 15), and the number of X and Y fields for each Z in integer fields of three columns each starting with column 16 and input in the same order as the Z values. The following cards contain the data in the order $Z_1, X_{11}, Y_{11}, X_{12}, Y_{12}, \dots, Z_2, X_{21}, Y_{21}, X_{22}, Y_{22}, \dots$ in real number fields of six columns each starting in column 1. The bivariant curve data input key is found in Table 3. An example of each curve type is given in Appendix A.

4.1.3 Input Routine Control Cards

The input routine control card follows a complete main input set of 25 cards and optional input curves and allows the user one of four options. If further variations in the nozzle independent variable-type inputs (cards 3 - 21) are

desired with the inclusion of a new title card, a 99 card (columns 2 and 3) containing the number of variation cards to follow (columns 5 and 6) is used. If no new title card is to follow but variation cards are included, an 88 card is used (8 in columns 2 and 3, the number of variation cards in columns 5 and 6). The variation input cards need contain only those data changed from the previous case but may not be used to change either fixed input or nozzle-dependent variable input. Additional optional data curves follow the variation cards but a new curve may not be used to replace a curve used in the basic case. If another basic case of 25 cards is to follow, an 888 card is used (columns 1, 2, and 3, all other columns blank) followed by the 25 cards and optional data curves. The input routine is terminated by the use of a 999 card. The arrangement of the input, curve, and control cards is shown in Figure 25.

4.2 PROGRAM OUTPUT

The aircraft geometric characteristics and internal and external performance parameters are printed at the end of each case. Input inconsistency or non-convergence of a program iterative routine causes the program to print an error message and advance to the next case. A discussion of the output format, including a listing of all the error messages, is presented below.

4.2.1 Format Description

The input title for the computer run is printed out at the beginning of each set of output data. This is followed by the configuration description (nozzle spacing, interfairing type, nozzle type, vertical stabilizer type, and clean or actual aircraft model) at the left side of the page. The aft-end geometric characteristics and the internal and external performance parameters are listed in four columns, each of which contains descriptive variable names and the associated input or computed value. The first (left hand) column lists the input flight conditions and computed performance parameters. The next column lists the fixed and nozzle-power setting dependent aircraft geometric parameters. Nozzle internal areas and exhaust flow characteristics are listed in the third column. The fourth and final column contains the boattail pressure and friction drags, the base drag, and the total aft-end drag in both force and coefficient forms. The drag coefficient reference area and the portion of the aircraft to which the analysis applies are defined by the comment lines printed out after the numerical data. Sample output pages are shown in Appendix A.

4.2.2 Error Messages

An inconsistent set of input data or a convergence failure in a program subroutine will result in an error message being printed out. When a situation causing an error message is encountered, the program ceases computation on the case being processed and proceeds to the next case. Each error message contains a brief description of the type of error and is generally self-explanatory. In the throat area iteration in the main routine, a location number is printed out in case of non-convergence identifying which of several similar iterations the case passed through.

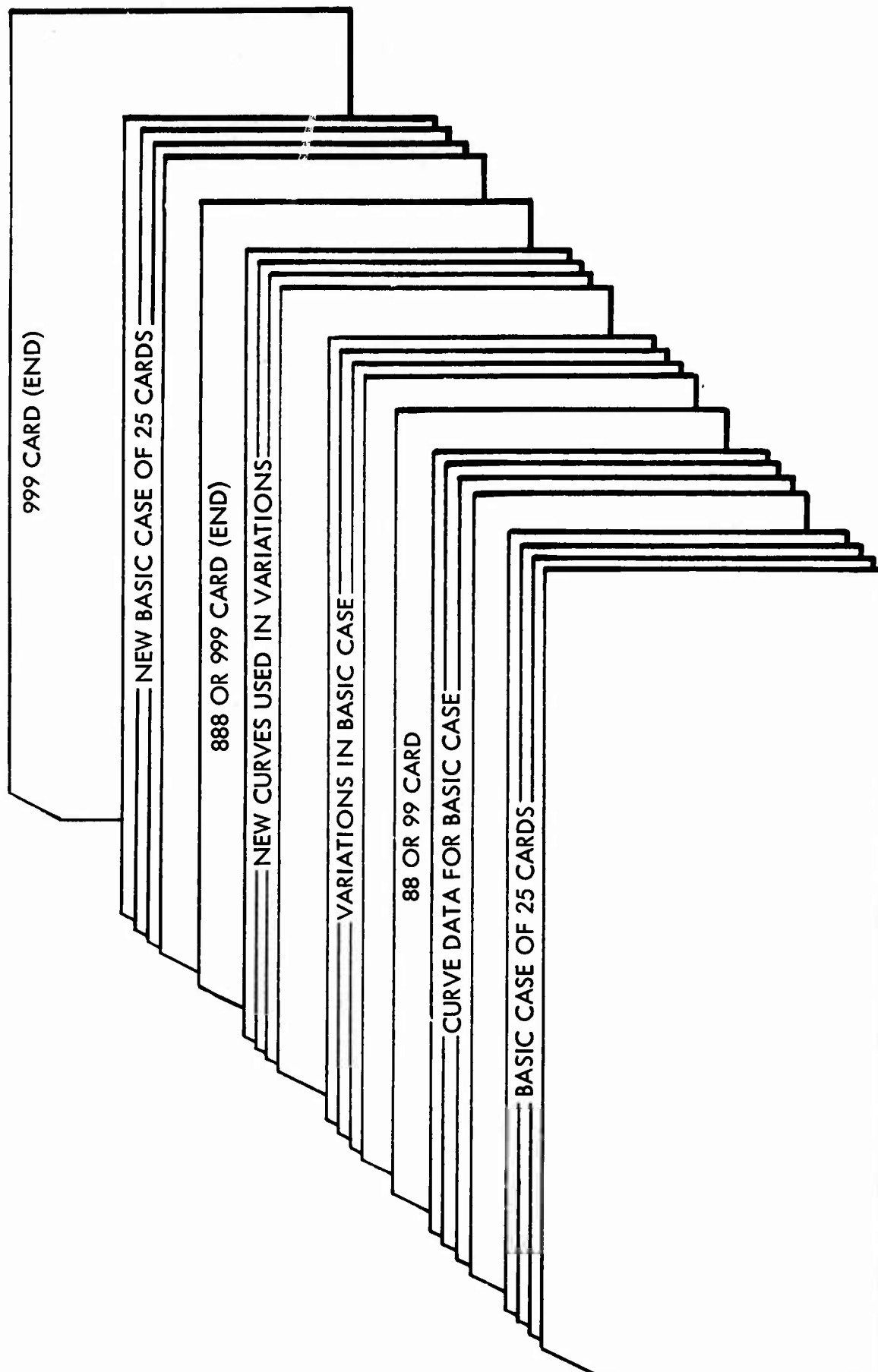


Figure 25. Data Deck Arrangement

Input inconsistencies found by the main program are as follows:

DIMENSIONAL FLIGHT SPEED INPUT REQUIRES AMBIENT PRESSURE AND
TEMPERATURE INPUTS
NON-STANDARD TEMPERATURE INCREMENT MAY BE USED ONLY WITH ALTITUDE
INPUT FOR PRESSURE
NON-UNITY DIVERGENCE AREA INPUT FOR NON-DIVERGING NOZZLE

Additional input data checks are made by nozzle performance subroutines.
Error messages from these checks are:

Subroutine EJECTR

SECONDARY FLOW TOTAL PRESSURE LESS THAN FREESTREAM STATIC

Subroutine NOZPLG

PLUG NOZZLE MUST BE CHOKED

Error messages which may result from non-convergence of iterative computations are as follows:

MAIN Routine

A_T WILL NOT CONVERGE

INPUT TEMPERATURE ITERATION WILL NOT CONVERGE

Subroutine AFTEND

REYNOLDS NUMBER ITERATION FAILED

EXTERNAL EXIT MACH NUMBER ITERATION FAILED

Subroutine EJECTR

PUMPING CHARACTERISTICS ITERATION FAILED

EXIT PRESSURE ITERATION FAILED

MACH NUMBER ITERATION FAILED

RECOMPRESSION PRESSURE GREATER THAN THROAT PRESSURE

UNCHOKED WSWP GREATER THAN CHOKED WSWP

Subroutine NOZZLE

NOZZLE THROAT AREA ITERATION FAILED

NOZZLE EXIT MACH NUMBER ITERATION FAILED

COMPUTED NOZZLE DIVERGENCE AREA LESS THAN UNITY

Subroutine NOZPLG

MACH NUMBER ITERATION FAILED AT LOCAL EXPANSION ANGLE

NOZZLE EXIT MACH NUMBER ITERATION FAILED

4.3 PROGRAM SETUP

The computer program has been written in FORTRAN IV compatible with the SCOPE 3.3 system for the CDC 6600 digital computer. The program requires 300,000 octal bytes of core, 20 seconds of run time per 100 cases, and standard input/output files, except an alternate file used by LSTDAT, described below.

The computer program source deck contains one main routine and 13 subroutines. These are listed below in hierarchical order, i.e., each indentation indicates that the subroutines in that list are first used by the subroutines in the preceding list.

MAIN

AFTEND
ATMØ2
EJECTR
FLTSPD
ITRATI
LSTDAT
NØZPLG
NØZZLE
XTRP

AREAS
ITERAT..
ITRATA
ITRATE

A brief description of each routine is provided below:

- MAIN - Processes input, calls subroutines, and prints results.
- AFTEND - Computes twin-nozzle/aftbody drag.
- ATMO2 - Obtains ambient pressure and temperature for the 1962 U.S. standard atmosphere.
- EJECTR - Computes thrust coefficient for a convergent-divergent ejector nozzle.
- FLTSPD - Provides freestream Mach number, true air speed, and indicated air speed provided one of these parameters is known.
- ITRATI - One-dimensional solution of a non-linear equation.
- LSTDAT - Reads in from regular input file, stores an alternate input file to be read by the program for the purpose of listing the input data
- NOZPLG - Computes thrust coefficient for shrouded and unshrouded plug nozzles.
- NOZZLE - Computes thrust coefficient for convergent and convergent-divergent nozzles.
- XTRP - Interpolates and extrapolates input data curves.
- AREAS - Determines area and Mach number for both primary and secondary ejector nozzle flow streams provided the pumping characteristics and static to total pressure ratios for one of the streams is known.
- ITERAT - Computes Mach number from the Prandtl-Meyer expansion angle.

ITRATA - N-dimensional non-linear simultaneous equation solution.

ITRATE - One-dimensional solution of a non-linear equation.

The order for deck assembly is standard. Job control cards are placed at the front, followed by the source deck containing the main routine and subroutines listed above. Cards with case input data including the input curves, follow the source deck. As noted earlier, only standard input and output files are required, except for the alternate file used by LSTDAT.

APPENDIX I
SAMPLE CASES

TITLE: Figure 27. Sample Computer Program Input - Case 2 (Continued)															PAGE	OF		
PREPARED BY										CHECKED BY					DATE	JOB NO.	GROUP	
																W.O.	EWA	
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76.77	80
IDC073	3	1	2	24	24											C-DE	26	
1.	0.		0.	.6	3.		.8	4.	.9		4.	1.1	5.	1.2		C-DE	27	
6.	1.4	7.	1.6	9.	1.8		1.8	10.	2.0		12.	2.2	13.	2.5		C-DE	28	
16.	11.	0.	0.	.6	3.		3.	.8	3.		.9	3.	1.1	5.		C-DE	29	
1.2	6.		1.4	7.	1.6		9.	1.8	10.		2.0	12.	2.2	13.		C-DE	30	
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76.77	80
2.5	16.															C-DE	31	
IDC102	2	1	16													C-DE	32	
.0322	76.5	.0644	58.	.0967	41.5	.1289	28.0	.1611	17.2	.1846	11.29					C-DE	33	
.1846	11.29	.2255	11.29													C-DE	34	
IDC123	2	1	18													C-DE	35	
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76.77	80
0.	1.	.0322	1.165	.0644	1.35	.0967	1.555	.1289	1.77	.1611	1.99					C-DE	36	
.1846	2.14	.1846	2.14	.2255	2.14											C-DE	37	
888																C-DE	38	
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76.77	80
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76.77	80

TITLE: Figure 29. Sample Computer Program Input - Case 4

PREPARED BY										CHECKED BY										DATE		DATE		JOB NO.		GROUP		PAGE		OF											
																												1		2											
																												ID		SEQ											
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80	TEST CASE 4 - UNSHROUDED PLUG NOZZLE - VARY ALTITUDE, CALC. IMSF, IMSA	U	PL	01																		
4	4	1	18.525	2.05	.873	.977	-1.	8.0												U	PL	02																			
3	1	1	0.9																	U	PL	03																			
4	2	220000.40000.																		U	PL	04																			
5	1	2	25.																	U	PL	05																			
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80	6	1	2	1.0																U	PL	06
7	1	1	4.0																	U	PL	07																			
8	1	1	1.4																	U	PL	08																			
9	1	1	.1795																	U	PL	09																			
10	1	1	0.																	U	PL	10																			
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80	11	1	1	6.															U	PL	11	
12	1	1	1.0																	U	PL	12																			
13	1	1	.1485																	U	PL	13																			
14	1	1	0.																	U	PL	14																			
15	1	1	24.																	U	PL	15																			
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80	16	1	1	20.															U	PL	16	
17	1	1	2.188																	U	PL	17																			
18	1	3																		U	PL	18																			
19	1	1	0.																	U	PL	19																			
20	1	1	.006																	U	PL	20																			
1	5	7	10	15	20	25	30	35	40	45	50	55	60	65	70	73	76	77	80	21	1	1	15.2															U	PL	21	
22	1	1	.2194																	U	PL	22																			
15.	.0315	.0865	.1795																	U	PL	23																			
																				U	PL	24																			
																				U	PL	25																			

(BLANK CARDS)

TEST CASE 1 - CONVERGENT-DIVERGENT NOZZLE - MAXIMUM THRUST-MINUS-DRAG

CONFIGURATION

NARROW SPACING
HORIZONTAL INTERFACING
CONVERGENT-DIVERGENT NOZZLE
SINGLE VERTICAL STABILIZER
CLEAN AIRCRAFT MODEL

FLIGHT CONDITIONS		FIXED AIRFRAME		NOZZLE PARAMETERS		AFT-END DRAG	
MACH NO	C.9000	WING AREA	18.52	FLOWING FULL		DBT PRESS	29.2
P AMB,PSF	630.0	MAX AREA	1.689	THROAT GEOM AREA	0.1850	DBT FRIC	9.4
T AMB,R	512.0	W.B. AREA	1.388	THROAT FLOW AREA	0.1839	D BASE	0.7
		INIT-BT LENGTH	2.326	EXIT AREA	0.2220	D TOTAL	38.3
		INIT-BT AMET	10.218	GAMMA	1.4000		
PERFORMANCE				CS	0.9965	CDBT PRESS	0.00441
PS	3.0000	VARIABLE AIRFRAME	0.014	CON	0.9940	CDBT FRIC	0.00127
PTJ/PAMB	5.0000	BASE AREA	1.217	WSWP	0.0	CD BASE	0.00011
CT	C.9930	TOTAL A FRONTAL	0.915	PTS/PTP	0.0	CD TOTAL	0.00579
C(T-DT)	C.9328	METRIC A FRONTAL	0.5940				
		IMSA	0.4367				
		IMST					

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF METRIC BREAK
ALL AREAS ARE IN SQUARE FEET

TEST CASE 1 - CONVERGENT-DIVERGENT NOZZLE - MAXIMUM THRUST-MINUS-DRAG

CONFIGURATION

NARROW SPACING
HORIZONTAL INTERFACING
CONVERGENT-DIVERGENT NOZZLE
SINGLE VERTICAL STABILIZER
CLEAN AIRCRAFT MODEL

FLIGHT CONDITIONS		FIXED AIRFRAME		NOZZLE PARAMETERS		AFT-END DRAG	
MACH NO	1.2000	WING AREA	18.52	FLOWING FULL		DBT PRESS	123.2
P AMB,PSF	630.0	MAX AREA	1.689	THROAT GEOM AREA	0.1850	DBT FRIC	25.2
T AMB,R	512.0	W.B. AREA	1.388	THROAT FLOW AREA	0.1839	D BASE	-1.8
		INIT-BT LENGTH	2.326	EXIT AREA	0.2812	D TOTAL	146.6
		INIT-BT AMET	10.218	GAMMA	1.4000		
PERFORMANCE				CS	0.9965	CDBT PRESS	0.01047
PS	3.0000	VARIABLE AIRFRAME	0.018	CON	0.9940	CDBT FRIC	0.00214
PTJ/PAMB	5.0000	BASE AREA	1.091	WSWP	0.0	CD BASE	-0.00015
CT	C.9920	TOTAL A FRONTAL	0.789	PTS/PTP	0.0	CD TOTAL	0.01247
C(T-DT)	C.7618	METRIC A FRONTAL	0.5940				
		IMSA	0.4272				
		IMST					

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF MAXIMUM AREA
ALL AREAS ARE IN SQUARE FEET

Figure 30. Sample Computer Program Output - Case 1

TEST CASE 2 - C-D EJECTOR NOZZLE - FLIGHT SPEED, ALTITUDE INPUT

CONFIGURATION

WIDE SPACING
HORIZONTAL INTERFAIRING
CONVERGENT-DIVERGENT EJECTOR NOZZLE
SINGLE VERTICAL STABILIZER
CLEAN AIRCRAFT MODEL

FLIGHT CONDITIONS		FIXED AIRFRAME		NOZZLE PARAMETERS		AFT-END DRAG	
MACH NO	0.8841	WING AREA	18.52	FLOWING FULL		DBT PRESS	7.3
P AMB,PSF	629.7	MAX AREA	2.050	THROAT GEOM AREA	0.0928	DBT FRIC	9.5
T AMB,R	415.1	M.B.AREA	1.790	THROAT FLOW AREA	0.0850	D BASE	0.4
		INIT.BT.LENGTH	1.578	EXIT AREA	0.1419	D TOTAL	17.2
PERFORMANCE		INIT.BT.AMET	16.400	GAMMA	1.4000		
PS	11.0000			CS	0.9970	COBT PRESS	0.00114
PTJ/PAMB	3.0000	VARIABLE AIRFRAME		CON	0.9161	COBT FRIC	0.00149
CT	6.9965	BASE AREA	0.007	WSP	0.2000	CD BASE	0.00007
C(T-DT)	0.8926	TOTAL A FRONTAL	1.752	PTS/PTP	0.4231	CD TOTAL	0.00270
		METRIC A FRONTAL	1.491				
		IMSA	0.7120				
		IMST	0.5900				

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF METRIC BREAK
ALL AREAS ARE IN SQUARE FEET

TEST CASE 2 - C-D EJECTOR NOZZLE - FLIGHT SPEED, ALTITUDE INPUT

CONFIGURATION

WIDE SPACING
HORIZONTAL INTERFAIRING
CONVERGENT-DIVERGENT EJECTOR NOZZLE
SINGLE VERTICAL STABILIZER
CLEAN AIRCRAFT MODEL

FLIGHT CONDITIONS		FIXED AIRFRAME		NOZZLE PARAMETERS		AFT-END DRAG	
MACH NO	0.8841	WING AREA	18.52	FLOWING FULL		DBT PRESS	7.3
P AMB,PSF	629.7	MAX AREA	2.050	THROAT GEOM AREA	0.0928	DBT FRIC	9.5
T AMB,R	415.1	M.B.AREA	1.790	THROAT FLOW AREA	0.0850	D BASE	0.4
		INIT.BT.LENGTH	1.578	EXIT AREA	0.1419	D TOTAL	17.2
PERFORMANCE		INIT.BT.AMET	16.400	GAMMA	1.4000		
PS	11.0000			CS	0.9970	COBT PRESS	0.00114
PTJ/PAMB	3.0000	VARIABLE AIRFRAME		CON	0.9161	COBT FRIC	0.00149
CT	6.9955	BASE AREA	0.007	WSP	0.4000	CD BASE	0.00007
C(T-DT)	0.9096	TOTAL A FRONTAL	1.752	PTS/PTP	0.6639	CD TOTAL	0.00269
		METRIC A FRONTAL	1.491				
		IMSA	0.7120				
		IMST	0.5900				

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF METRIC BREAK
ALL AREAS ARE IN SQUARE FEET

Figure 31. Sample Computer Program Output - Case 2

TEST CASE 2 - C-D EJECTOR NOZZLE - FLIGHT SPEED, ALTITUDE INPUT

CONFIGURATION

WIDE SPACING
HORIZONTAL INTERFAIRING
CONVERGENT-DIVERGENT EJECTOR NOZZLE
SINGLE VERTICAL STABILIZER
CLEAN AIRCRAFT MODEL

FLIGHT CONDITIONS		FIXED AIRFRAME		NOZZLE PARAMETERS		AFT-END DRAG	
MACH NO	1.1788	WING AREA	16.52	FLOWING FULL		DBT PRESS	274.4
P AMB,PSF	629.7	MAX AREA	2.050	THROAT GEOM AREA		DBT FRIC	32.0
T AMB,R	375.6	M-B AREA	1.790	THROAT FLOW AREA	0.0928	D BASE	-5.2
		INIT,BT-LENGTH	1.578	EXIT AREA	0.0850	D TOTAL	301.2
PERFORMANCE		INIT,BT AWET	16.400	GAMMA	0.1419		
PS	11.0000			CS	1.4000		
PTJ/PAMB	5.7878	VARIABLE AIRFRAME		CDN	0.9970	CDBT PRESS	0.02418
CT	0.9906	BASE AREA	0.007	MSWP	0.9161	CDBT FRIC	0.00282
CIT-DTJ	0.2482	TOTAL A FRONTAL	1.752	PTS/PTP	0.2000	CD BASE	-0.00046
		METRIC A FRONTAL	1.491		0.4231	CD TOTAL	0.02655
		IMSA	0.7120				
		IMST	0.5900				

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF MAXIMUM AREA
ALL AREAS ARE IN SQUARE FEET

TEST CASE 2 - C-D EJECTOR NOZZLE - FLIGHT SPEED, ALTITUDE INPUT

CONFIGURATION

WIDE SPACING
HORIZONTAL INTERFAIRING
CONVERGENT-DIVERGENT EJECTOR NOZZLE
SINGLE VERTICAL STABILIZER
CLEAN AIRCRAFT MODEL

FLIGHT CONDITIONS		FIXED AIRFRAME		NOZZLE PARAMETERS		AFT-END DRAG	
MACH NO	1.1788	WING AREA	16.52	FLOWING FULL		DBT PRESS	274.4
P AMB,PSF	629.7	MAX AREA	2.050	THROAT GEOM AREA	0.0928	DBT FRIC	32.0
T AMB,R	375.6	M-B AREA	1.790	THROAT FLOW AREA	0.0850	D BASE	-6.3
		INIT,BT-LENGTH	1.578	EXIT AREA	0.1419	D TOTAL	300.1
PERFORMANCE		INIT,BT AWET	16.400	GAMMA	1.4000		
PS	11.0000			CS	0.9970	CDBT PRESS	0.02418
PTJ/PAMB	5.7878	VARIABLE AIRFRAME		CDN	0.9161	CDBT FRIC	0.00282
CT	0.9753	BASE AREA	0.007	MSWP	0.4000	CD BASE	-0.00055
CIT-DTJ	0.3491	TOTAL A FRONTAL	1.752	PTS/PTP	0.6639	CD TOTAL	0.02645
		METRIC A FRONTAL	1.491				
		IMSA	0.7120				
		IMST	0.5900				

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF MAXIMUM AREA
ALL AREAS ARE IN SQUARE FEET

Figure 31. Sample Computer Program Output - Case 2 (Continued)

TEST CASE 3 - CONVERGENT NOZZLE - CALCULATE IMSE, INSA FROM AREA DIST.

CONFIGURATION
NARROW SPACING
HORIZONTAL INTERFAIRING
CONVERGENT NOZZLE
SINGLE VERTICAL STABILIZER
CLEAN AIRCRAFT MODEL

FLIGHT CONDITIONS	FIXED AIRFRAME	NOZZLE PARAMETERS	AFT-END DRAG
MACH NO	WING AREA	FLOWING FULL	DBT PRESS
P AMB,PSF	MAX AREA	THROAT GEOM AREA	DBT FRIC
T AMB,R	M-B AREA	THROAT FLOW AREA	D BASE
	INIT-BT LENGTH	EXIT AREA	D TOTAL
	INIT-BT AREA	GAMMA	
PERFORMANCE		CS	CDBT PRESS
PS	VARIABLE AIRFRAME	CDN	CDBT FRIC
PTJ/PAMB	BASE AREA	WSWP	CD BASE
CT	TOTAL A FRONTAL	PTS/PTP	CD TOTAL
C(T-DT)	METRIC A FRONTAL		
	IMSA		
	IMST		

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF METRIC BREAK
ALL AREAS ARE IN SQUARE FEET

TEST CASE 3 - CONVERGENT NOZZLE - CALCULATE IMSE, INSA FROM AREA DIST.

CONFIGURATION
NARROW SPACING
HORIZONTAL INTERFAIRING
CONVERGENT NOZZLE
SINGLE VERTICAL STABILIZER
CLEAN AIRCRAFT MODEL

FLIGHT CONDITIONS	FIXED AIRFRAME	NOZZLE PARAMETERS	AFT-END DRAG
MACH NO	WING AREA	FLOWING FULL	DBT PRESS
P AMB,PSF	MAX AREA	THROAT GEOM AREA	DBT FRIC
T AMB,R	M-B AREA	THROAT FLOW AREA	D BASE
	INIT-BT LENGTH	EXIT AREA	D TOTAL
	INIT-BT AREA	GAMMA	
PERFORMANCE		CS	CDBT PRESS
PS	VARIABLE AIRFRAME	CDN	CDBT FRIC
PTJ/PAMB	BASE AREA	WSWP	CD BASE
CT	TOTAL A FRONTAL	PTS/PTP	CD TOTAL
C(T-DT)	METRIC A FRONTAL		
	IMSA		
	IMST		

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF METRIC BREAK
ALL AREAS ARE IN SQUARE FEET

Figure 32. Sample Computer Program Output - Case 3

TEST CASE 4 - UNSHROUDED PLUG NOZZLE - VARY ALTITUDE, CALC. IMSP, INSA

CONFIGURATION
WIDE SPACING
HORIZONTAL INTERFACING
UNSHROUDED PLUG NOZZLE
TWIN VERTICAL STABILIZERS
ACTUAL AIRCRAFT

FLIGHT CONDITIONS	FIXED AIRFRAME	NOZZLE PARAMETERS	AFT-END DRAG
MACH NO 0.9000	WING AREA 18.52	FLOWING FULL	DBT PRESS 13.4
P AMB,PSF 972.5	MAX AREA 2.050	THROAT GEOM AREA	DBT FRIC 15.5
T AMB,R 472.3	P-B AREA 1.790	THROAT FLOW AREA	D BASE 2.8
	INIT-BT LENGTH 1.578	EXIT AREA	D TOTAL 31.6
PERFORMANCE	INIT-BT AREA 16.400	GAMMA	
PS 1.0000	VARIABLE AIRFRAME	CS	CDBT PRESS 0.00131
PTJ/PAMB 4.0000	BASE AREA	CDN	CDBT FRIC 0.00151
CT 0.9705	TOTAL A FRONTAL 1.711	WSMP	CD BASE 0.00028
C(T-DT) 0.9259	METRIC A FRONTAL 1.451	PTS/PTP	CD TOTAL 0.00309
	INSA 0.5996		
	INST 0.5002		

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF METRIC BREAK
ALL AREAS ARE IN SQUARE FEET

TEST CASE 4 - UNSHROUDED PLUG NOZZLE - VARY ALTITUDE, CALC. IMSP, INSA

CONFIGURATION
WIDE SPACING
HORIZONTAL INTERFACING
UNSHROUDED PLUG NOZZLE
TWIN VERTICAL STABILIZERS
ACTUAL AIRCRAFT

FLIGHT CONDITIONS	FIXED AIRFRAME	NOZZLE PARAMETERS	AFT-END DRAG
MACH NO 0.9000	WING AREA 18.52	FLOWING FULL	DBT PRESS 5.4
P AMB,PSF 391.7	MAX AREA 2.050	THROAT GEOM AREA	DBT FRIC 7.0
T AMB,R 415.0	P-B AREA 1.790	THROAT FLOW AREA	D BASE 1.1
	INIT-BT LENGTH 1.578	EXIT AREA	D TOTAL 13.5
PERFORMANCE	INIT-BT AREA 16.400	GAMMA	
PS 1.0000	VARIABLE AIRFRAME	CS	CDBT PRESS 0.00131
PTJ/PAMB 4.0000	BASE AREA	CDN	CDBT FRIC 0.00169
CT 0.9705	TOTAL A FRONTAL 1.711	WSMP	CD BASE 0.00028
C(T-DT) 0.9233	METRIC A FRONTAL 1.451	PTS/PTP	CD TOTAL 0.00328
	INSA 0.5996		
	INST 0.5002		

ALL DRAGS FOR TWO NOZZLES
DRAG COEFFICIENTS REFERENCED TO WING AREA
DRAGS ARE FOR AFT-END AFT OF METRIC BREAK
ALL AREAS ARE IN SQUARE FEET

Figure 33. Sample Computer Program Output - Case 4

APPENDIX II
PROGRAM LISTINGS

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DIMENSION DOB1( 171),DOB1( 8),RCRTCD(32),FIG5(32),DOB2(45)          MAIN 000
DIMENSION AA(50), XX(50), JIFF(49), F32181(35), NVARY(24)          MAIN 001
DIMENSION IDC072(50),IDC073(300),IDC082(50),IDC092(50),IDC094(50),MAIN 002
1 IDC102(50),IDC112(50),IDC123(50),IDC132(50),IDC142(50),IDC152(50)MAIN 003
2 ,IDC162(50),IDC172(50),IDC182(50),IDC183(100),IDC192(50),      MAIN 004
3 IDC202(50),                                                    MAIN 005
3 IDC203(300),IDC212(50),IDC222(50),IDC232(50),IDC234(50),      MAIN 006
4 IDC242(50),IBLK(23),IDC(1700),INCURV(22),CURV(300)          MAIN 007
DIMENSION TITLF(18),QIN(30,10),INUM(30),ICODE(30)          MAIN 008
EQUIVALENCE (IDC(1),IDC072(1)),(IDC( 51), IDC073(1))          MAIN 009
1(IDC(351),IDC082(1)),(IDC(401),IDC092(1)),(IDC(451),IDC094(1)), MAIN 010
2(IDC(501),IDC102(1)),(IDC(551),IDC112(1)),(IDC(601),IDC123(1)), MAIN 011
3(IDC(651),IDC132(1)),(IDC(701),IDC142(1)),(IDC(751),IDC152(1)), MAIN 012
4(IDC(801),IDC162(1)),(IDC(851),IDC172(1)),(IDC(901),IDC182(1)), MAIN 013
6(IDC( 951),IDC183(1)),(IDC(1051),IDC192(1)),(IDC(1101),IDC202(1)),MAIN 014
6(IDC(1401),IDC203(1)),(IDC(1451),IDC212(1)),(IDC(1501),IDC222(1)),MAIN 015
7(IDC(1550),IDC232(1)),(IDC(1601),IDC234(1)),(IDC(1651),IDC242(1)) MAIN 016
EQUIVALENCE (INUM3,INUM(3)),(INUM4,INUM(4)),(INJM5,INUM(5)),    MAIN 017
1(INJM6,INUM( 6)),(INUM7,INUM( 7)),(INUM8,INUM( 8)),          MAIN 018
2(INJM9,INUM( 9)),(INUM10,INUM(10)),(INUM11,INUM(11)),        MAIN 019
3(INJM12,INUM(12)),(INUM13,INUM(13)),(INUM14,INUM(14)),      MAIN 020
4(INJM15,INUM(15)),(INUM16,INUM(16)),(INUM17,INUM(17)),      MAIN 021
5(INJM18,INUM(18)),(INUM19,INUM(19)),(INUM20,INUM(20)),      MAIN 022
6(INJM21,INUM(21)),(INUM22,INUM(22)),(INUM23,INUM(23)),      MAIN 023
7(INJM24,INUM(24))          MAIN 024
DATA DOB/ *NARR*,*JW S*,*PACI*,*NG **, **, **, **, **,MAIN 025
1* *, *INTE*,*RMED*,*IATE*,* SPA*,*CING*,* **, **, **, **,MAIN 026
2* *, *WIDE*,* SPA*,*CING*,* **, **, **, **, **,MAIN 027
3* *, *WIDE*,* SPA*,*CING*,* **, **, **, **, **,MAIN 028
4* *, *HORI*,*ZONT*,*AL I*,*INTER*,*FAIR*,*ING **, **, **,MAIN 029
5* *, *VERT*,*ICAL*,* INT*,*ERFA*,*IRIN*,*G **, **, **,MAIN 030
6* *, *CONV*,*ERGE*,*NT N*,*OZZL*,*E **, **, **,MAIN 031
7* *, *CONV*,*ERGE*,*NT-D*,*IVER*,*GENT*,* NOZ*,*ZLE **, **,MAIN 032
8* *, *CONV*,*ERGE*,*NT-D*,*IVER*,*GENT*,* EJE*,*CTOR*,* NOZ*,MAIN 033
9*ZLE *, *UNSH*,*ROUD*,*ED P*,*LUG **, *NOZZ*,*LE **, **,MAIN 034
A* *, *SHRO*,*UDED*,* PLU*,*G NO*,*ZZLE*,* **, **, **,MAIN 035
B* *, *SING*,*LE V*,*ERTI*,*CAL **, *STAB*,*ILIZ*,*ER **, **,MAIN 036
C* *, *TWIN*,* VER*,*TICA*,*L ST*,*ABIL*,*IZFR*,*S **, **,MAIN 037
D* *, *CLEA*,*N AI*,*RCRA*,*FT M*,*ODEL*,* **, **, **,MAIN 038
E* *, *ACTU*,*AL A*,*IRCR*,*AFT **, **, **, **,MAIN 039
F* */          MAIN 040
DATA DOB2/*SUBS*,*JNIC*,* FLO*,*W (U*,*NCHO*,*CKED*,*) **, **,MAIN 041
G* *, *SEPA*,*RATE*,*J-CU*,*SP I*,*INTER*,*POLA*,*TION*,* **,MAIN 042
H* *, *SEPA*,*RATE*,*D FL*,*OW **, **, **, **, **,MAIN 043
I* *, *FLOW*,*ING **, *FULL*,* **, **, **, **, **,MAIN 044
J* *, *CRIT*,*ICAL*,*-UNC*,*HOKF*,*D **, **, **, **, **,MAIN 045
K* */          MAIN 046
DATA DOB1/*METR*,*IC B*,*REAK*,* **, *MAXI*,*MJM **, *AREA*,* */MAIN 047
INTEGER O          MAIN 048
REAL L480M,IMSF,LEXP, IDC ,LP,LMB          MAIN 049
REAL IDC072,IDC073,IDC082,IDC092,IDC094,IDC102,IDC112,IDC123, MAIN 050
1 IDC132,IDC142,IDC152,IDC162,IDC172,IDC182,IDC192,IDC202,IDC203, MAIN 051
2 IDC212,IDC222,IDC232,IDC234,IDC242,IDC183          MAIN 052
DATA IBLK/0, 350, 400, 500, 550, 600, 550, 700, 750, 800,MAIN 053
1 850, 900, 1050, 1100, 1450, 1500, 1500, 1650/ MAIN 054
F3(TERM1)=3.5-SIN(23.8062*(TERM1-.95))/COS(23.8062*(TERM1-.95)) MAIN 055
C2(TRM1) = 8.E-6/((TRM1-.965)**2+4.E-4)          MAIN 056
C3(TRMX) = .0011-.00205*SIN(74.8*(TRMX -.952))+((.92-TRMX)*.0574+ MAIN 057
1 ABS((.92-TRMX)*.0574))/2.          MAIN 058

```

	F4(TARM1,TARM2)=TARM1-C2(TARM1)*(TARM2-F3(TARM1))**2+C3(TARM1)	MAIN 059
	1 *(TARM2-F3(TARM1))**3	MAIN 060
	DATA RCRTCD / 2., 1., 0., 28.,	MAIN 061
A	0., .883, .05, .9, .1, .917, .15, .932,	MAIN 062
B	.2, .943, .3, .961, .4, .972, .5, .977,	MAIN 063
C	.6, .981, .8, .986, 1.0, .989, 1.2, .992,	MAIN 064
D	1.6, .995, 2.0, .996 /	MAIN 065
	DATA FIG5 / 2., 1., 0., 28.,	MAIN 066
1	0., .998, 5., .988, 10., .978, 15., .968,	MAIN 067
2	20., .958, 25., .947, 30., .937, 35., .929,	MAIN 068
3	40., .921, 50., .908, 60., .897, 70., .888,	MAIN 069
4	80., .882, 90., .877 /	MAIN 070
	DATA FG2181 / 2., 1., 0., 32.,	MAIN 071
A	0., .953, 1., .96, 2., .966, 3., .971,	MAIN 072
B	4., .975, 5., .978, 6., .98, 7., .982,	MAIN 073
C	8., .983, 9., .984, 10., .9849, 11., .9851,	MAIN 074
D	12., .9855, 13., .9858, 14., .9859, 15., .9859 /	MAIN 075
	D=3	MAIN 076
	CAL LSTDAT(N)	MAIN 077
	IND = 888	MAIN 078
	IVARY = 19	MAIN 079
	DJ 1 I = 1,22	MAIN 080
1	NVARY(I) = 0	MAIN 081
	PI = 3.1415927	MAIN 082
	GAMFS = 1.4	MAIN 083
	RZR = 1716.5	MAIN 084
	GRAV = 32.174	MAIN 085
	RAD = .017453	MAIN 086
5	READ(0,1000)TITLE	MAIN 087
	INUM22=1	MAIN 088
	INUM23=1	MAIN 089
	INUM24=1	MAIN 090
	IF(IND .EQ. 888)	MAIN 091
	1 READ(0,1010) ISO,NT,IT,AWING,AM,AMBAM,LMBDM,IMSF,AWFAM	MAIN 092
6	DJ 10 J = 1,IVARY	MAIN 093
	READ(0,1015) ICARD,INUM(ICARD),ICODE(ICARD), (QIN(ICARD,I),I=1,10)	MAIN 094
	IF(IND .NE. 888) NVARY(ICARD) = ICARD	MAIN 095
10	CONTINUE	MAIN 096
	IF(NVARY(4) .EQ. 0 .AND. IND. NE. 888) GO TO 250	MAIN 097
	IF(ICODE(4) .NE. 4) GO TO 12	MAIN 098
	DJ 11 I=1,10	MAIN 099
11	QIN(4,I)=QIN(4,I)*1.E6	MAIN 100
	IF(NVARY(4) .NE. 0) GO TO 250	MAIN 101
12	IF (NT .NE. 1) GO TO 15	MAIN 102
	READ(0,1020)ATMIN,ATMAX,0,2,(0,I=1,12)	MAIN 103
	GO TO 25	MAIN 104
15	IF (NT .NE. 2) GO TO 20	MAIN 105
	READ(0,1020)FL,AEATMN,AEATMX	MAIN 106
	READ(0,1020)(Q,I=1,12)	MAIN 107
	GO TO 25	MAIN 108
20	IF(NT .NE. 3) GO TO 24	MAIN 109
	DJ 21 J=1,3	MAIN 110
21	READ(0,1015)ICARD,INUM(ICARD),ICODE(ICARD), (QIN(ICARD,I),I=1,10)	MAIN 111
	READ(0,1020)LEXP,AEATMN,AEATMX,GAMS	MAIN 112
	GO TO 25	MAIN 113
24	READ(0,1015)ICARD,INUM(ICARD),ICODE(ICARD), (QIN(ICARD,I),I=1,10)	MAIN 114
	READ(0,1030)ALPHAP,APB,ATMIN,ATMAX,AEATMN,AEATMX	MAIN 115

***CONTINUING

	READ(0,1020)(Q,I=1,8)	MAIN 116
25	IF(ICODE(12).EQ.4 .AND. NT.GT.1)DAEAT=(AEATMX -AEATMN)/20.	MAIN 117
	IF(IMS F .GE. 0.) GO TO 250	MAIN 118
	READ(0,1040)(INCURV(J),J=1,22)	MAIN 119
	NIMS F = INCURV(3)/2	MAIN 120
	READ(0,1030) ((XX(I),AA(I)),I=1,NIMS F)	MAIN 121
	NIM1 = NIMS F-1	MAIN 122
	SA = 0.	MAIN 123
	DJ 370 I=1,NIM1	MAIN 124
370	DIFF(I)=(AA(I+1)-AA(I))/(XX(I+1)-XX(I))	MAIN 125
	DJ 380 I = 1,NIM1	MAIN 126
	ADIFF =-AA(I+1)+AA(I)	MAIN 127
380	SA = ADIFF*DIFF(I) +ADIFF*(DIFF(I+1)-DIFF(I))/2. + SA	MAIN 128
	IMS F = SA/(1.-AA(NIMS F))	MAIN 129
	IMS F = ABS(IMS F)	MAIN 130
250	IF(IND .NE. 888) GO TO 265	MAIN 131
	DJ 26 I=1,1700	MAIN 132
26	IDC(I) = 0.	MAIN 133
265	DJ 30 I=7,24	MAIN 134
	IF(IND .NE. 888 .AND. NVARY(I) .EQ. 0) GO TO 30	MAIN 135
	ILJC = IBLK(I-E)	MAIN 136
	IF(I .EQ. 7 .AND. ICODE(7) .EQ. 3) ILOC=ILOC+50	MAIN 137
	IF(I.EQ. 9 .AND. ICODE(9).EQ.4)ILOC=ILOC+50	MAIN 138
	IF(I .EQ. 20 .AND. ICODE(20) .EQ. 3) ILOC=ILOC+300	MAIN 139
	IF(I.EQ.18 .AND. ICODE(18).EQ.3)ILOC=ILOC+50	MAIN 140
	IF(I.EQ.23 .AND. ICODE(23).EQ.4)ILOC=ILOC+50	MAIN 141
	IF(NT.NE.3 .AND. I.GE.22)GO TO 30	MAIN 142
	IF (ICODE(I) .EQ. 1)GO TO 30	MAIN 143
	IF (ICODE(I) .EQ. 3 .AND.(I .EQ. 9 .OR. I .EQ.23))	MAIN 144
	GO TO 30	MAIN 145
	IF(ICODE(I) .EQ. 4 .AND.(I.EQ.20 .OR. I.EQ.12))GO TO 30	MAIN 146
	IF(ICODE(I).EQ.2.AND.I.EQ.12)GO TO 30	MAIN 147
	IF(I.GT.22 .AND. ICODE(I).EQ.3) GO TO 30	MAIN 148
	READ(0,1040)(INCURV(J),J=1,22)	MAIN 149
	IN = INCURV(3)	MAIN 150
	IF(ICODE(I) .NE. 3) GO TO 29	MAIN 151
	IF(I .EQ. 12 .OR. I.EQ.18)GO TO 29	MAIN 152
C***B	IVARIATE	MAIN 153
	NUMZ = INCURV(3)	MAIN 154
	NUMZ4=NUMZ+3	MAIN 155
	ZMAX = 0.	MAIN 156
	IK=0	MAIN 157
	IZSUM = 0.	MAIN 158
	DJ 27 J= 4,NUMZ4	MAIN 159
	IZSUM = IZSUM + INCURV(J)	MAIN 160
27	ZMAX = AMAX1(FLOAT(INCURV(J)),ZMAX)	MAIN 161
	IZMAX=ZMAX	MAIN 162
	IZMX1=IZMAX+1	MAIN 163
	NUMZXY = 2 + IZSUM	MAIN 164
	READ(0,1030) (CURV(K),K=1,NUMZXY)	MAIN 165
	DJ 28 IR = 1,NUMZ	MAIN 166
	IZ = INCURV(IR+3)+1	MAIN 167
	DJ 280 IS=1,IZ	MAIN 168
280	IDC(ILOC+IK+6+IS)=CURV(IS+IZMX1*(IR-1))	MAIN 169
	IDC(ILOC+IK+6)=IZ-1	MAIN 170
	IK = IK+ IZ + 1	MAIN 171
28	CONTINUE	MAIN 172

***CONTINJING

	IDC(ILOC+5) = INCURV(3)	MAIN 173
	IDC(ILOC+4) = ZMAX + 2.	MAIN 174
	IDC(ILOC+1) = INCURV(1)	MAIN 175
	IDC(ILOC+2) = INCURV(2)	MAIN 176
	GO TO 30	MAIN 177
29	IDC(ILOC+4) = INCURV(3)	MAIN 178
	IDC(ILOC+1) = INCURV(1)	MAIN 179
	IDC(ILOC+2) = INCURV(2)	MAIN 180
	READ(0,1030)(IDC(J+ILOC+4),J=1,IN)	MAIN 181
30	CJNTINUE	MAIN 182
	DM = 2.*SQRT(AM/PI)	MAIN 183
	LPRINT = 2	MAIN 184
390	IF(ICODE(18) .NE. 3) GO TO 40	MAIN 185
	SA = 0.	MAIN 186
	AMAMB = 1./AMBAM	MAIN 187
	DMOMB = 1./SQRT(AMBAM)	MAIN 188
	NIMSA = IDC183(4)/2.	MAIN 189
	NIMAI = NIMSA-1	MAIN 190
	DO 395 I = 1,NIMSA	MAIN 191
	XX(I) = (IDC183(2*I+3)-LMBDM)*DMOMB	MAIN 192
	AA(I) = IDC183(2*I+4)*AMAMB	MAIN 193
	IF(I.GE. 2) DIFF(I-1) = (AA(I)-AA(I-1))/(XX(I)-XX(I-1))	MAIN 194
395	CJNTINUE	MAIN 195
	DO 397 I = 1,NIMAI	MAIN 196
397	SA = (AA(I)-AA(I+1))*DIFF(I) + (AA(I)-AA(I+1))*(DIFF(I+1)-DIFF(I))/2.	MAIN 197
	I + SA	MAIN 198
	QIN(18,1) = SA/(1.-AA(NIMSA))	MAIN 199
	QIN(18,1) = ABS(QIN(18,1))	MAIN 200
40	DO 3003 I3=1,INUM3	MAIN 201
	DO 3004 I4=1,INUM4	MAIN 202
	DO 3005 I5=1,INUM5	MAIN 203
	DO 3006 I6=1,INUM6	MAIN 204
	DO 3007 I7=1,INUM7	MAIN 205
	DO 3008 I8=1,INUM8	MAIN 206
	DO 3009 I9=1,INUM9	MAIN 207
	DO 3010 I10=1,INUM10	MAIN 208
	DO 3011 I11=1,INUM11	MAIN 209
	DO 3012 I12=1,INUM12	MAIN 210
	DO 3013 I13=1,INUM13	MAIN 211
	DO 3014 I14=1,INUM14	MAIN 212
	DO 3015 I15=1,INUM15	MAIN 213
	DO 3016 I16=1,INUM16	MAIN 214
	DO 3017 I17=1,INUM17	MAIN 215
	DO 3018 I18=1,INUM18	MAIN 216
	DO 3019 I19=1,INUM19	MAIN 217
	DO 3020 I20=1,INUM20	MAIN 218
	DO 3021 I21=1,INUM21	MAIN 219
	DO 3022 I22=1,INUM22	MAIN 220
	DO 3023 I23=1,INUM23	MAIN 221
	DO 3024 I24=1,INUM24	MAIN 222
	V3 = QIN(C3,I3)	MAIN 223
	V4 = QIN(C4,I4)	MAIN 224
	V5 = QIN(C5,I5)	MAIN 225
	V6 = QIN(C6,I6)	MAIN 226
	V7 = QIN(C7,I7)	MAIN 227
	V8 = QIN(C8,I8)	MAIN 228
	V9 = QIN(C9,I9)	MAIN 229

V10	=QIN(10,I10)	MAIN 230
V11	=QIN(11,I11)	MAIN 231
V12	=QIN(12,I12)	MAIN 232
V13	=QIN(13,I13)	MAIN 233
V14	=QIN(14,I14)	MAIN 234
V15	=QIN(15,I15)	MAIN 235
V16	=QIN(16,I16)	MAIN 236
V17	=QIN(17,I17)	MAIN 237
V18	=QIN(18,I18)	MAIN 238
V19	=QIN(19,I19)	MAIN 239
V20	=QIN(20,I20)	MAIN 240
V21	=QIN(21,I21)	MAIN 241
V22	=QIN(22,I22)	MAIN 242
V23	=QIN(23,I23)	MAIN 243
V24	=QIN(24,I24)	MAIN 244
V209	= 0.	MAIN 245
FLAG3	= 0.	MAIN 246
ITMD	= 0	MAIN 247
	IF(ICODE(3) .GE. 2) GO TO 35	MAIN 248
C ICODE(3) = 1	SECTION ****	MAIN 249
	IF (ICODE(4) .NE. 1) GO TO 31	MAIN 250
	IF (ICODE(5) .EQ. 1) GO TO 47	MAIN 251
	IF(ICODE(5) .EQ. 2) GO TO 2001	MAIN 252
	V5 = QIN(5,I5)/(1.+2*QIN(3,I3)**2)	MAIN 253
	GO TO 47	MAIN 254
31	IF (ICODE(4) .NE. 2) GO TO 33	MAIN 255
	GEOPA = QIN(4,I4)/(QIN(4,I4)/2.084482E7 + 1.)	MAIN 256
32	CALL ATM02(GEOPA, 0., V5, V4, ERR)	MAIN 257
	IF(ICODE(5) .EQ. 1) V5 = QIN(5,I5)	MAIN 258
	IF(ICODE(5) .EQ. 2) V5 = V5 + QIN(5,I5)	MAIN 259
	IF(ICODE(5) .EQ. 3) V5 = QIN(5,I5)/(1.+2*QIN(3,I3)**2)	MAIN 260
	GO TO 47	MAIN 261
33	IF(ICODE(4) .NE. 3) GO TO 34	MAIN 262
	GEOPA = QIN(4,I4)	MAIN 263
	GO TO 32	MAIN 264
34	IF(ICODE(5) .EQ. 2) GOTO 2001	MAIN 265
	IF(ICODE(5) .EQ. 3) V5 = QIN(5,I5)/(1.+2*QIN(3,I3)**2)	MAIN 266
	V4 = QIN(4,I4)*RRR*V5*2.27E-8*(V5)**(1.5)/(V3*SQRT(GAMFS*RRR*V5)*	MAIN 267
	1 (V5+198.6))	MAIN 268
	GO TO 47	MAIN 269
C ICODE(3) = 2	SECTION ****	MAIN 270
35	IF(ICODE(4) .NE. 1) GO TO 37	MAIN 271
	IF(ICODE(5) .EQ. 2) GO TO 2001	MAIN 272
	IF(ICODE(5) .EQ. 3) GO TO 2000	MAIN 273
36	CAL FLTSPD(ICODE(3), QIN(3,I3), V3, VK, VM, VI, VMI, V4, V5)	MAIN 274
	IF(ICODE(5) - 3) 47,38,38	MAIN 275
37	IF(ICODE(4) .NE. 2) GO TO 39	MAIN 276
	GEOPA = QIN(4,I4)/(QIN(4,I4)/2.084482E7 + 1.)	MAIN 277
361	CAL ATM02(GEOPA, 0., V5, V4, ERR)	MAIN 278
	IF(ICODE(5) .EQ. 1) V5 = QIN(5,I5)	MAIN 279
	IF(ICODE(5) .EQ. 2) V5 = QIN(5,I5)+V5	MAIN 280
	IF(ICODE(5) .NE. 3) GO TO 36	MAIN 281
	KT = 0	MAIN 282
	GO TO 36	MAIN 283
38	TTF = V5*(1. + .2*V3**2)-QIN(5,I5)	MAIN 284
	SAVV5 = V5	MAIN 285
	CALL ITRATE (V5, TTF, 0., KT)	MAIN 286

***CONTINJING

	IF(ABS(TTF) .LT. 001) GO TO 47	MAIN 287
	IF(<T .GT. 25) GO TO 2007	MAIN 288
	IF(SAVV5 -V5 .GT. 0.) V5 = AMAX1(V5, .8*SAVV5)	MAIN 289
	IF(SAVV5 -V5 .LT. 0.) V5 = AMIN1(V5, 1.2*SAVV5)	MAIN 290
	IF(<T .EQ. 1) V5 = 1.01*V5	MAIN 291
	GO TO 38	MAIN 292
39	IF(ICODE(4) .NE. 3) GO TO 2000	MAIN 293
	GEOPA = DIN(4,14)	MAIN 294
	GO TO 361	MAIN 295
47	IF(ICODE(7).LE.1) GO TO 49	MAIN 296
	IF(ICODE(7).GE.3) GO TO 48	MAIN 297
	CALL XTRP (V3 ,V7,0.,IDC072)	MAIN 298
	GO TO 49	MAIN 299
48	CALL XTRP (V3,V7,V6,IDC073)	MAIN 300
49	IF (ICODE(8).LE.1) GO TO 50	MAIN 301
	CALL XTRP (V6,V8,0.,IDC082)	MAIN 302
50	IF(NT.GE.4) GO TO 127	MAIN 303
	IF(ICODE(9).GE.3) GO TO 66	MAIN 304
	IF(ICODE(9).LE.1) GO TO 54	MAIN 305
	CALL XTRP (V3,V9,0.,IDC092)	MAIN 306
54	IF (ICODE(10).LE.1) GO TO 56	MAIN 307
55	CALL XTRP(V9,V10,0.,IDC102)	MAIN 308
56	IF (ICODE(11).LE.1) GO TO 58	MAIN 309
	CALL XTRP(V9,V11,0.,IDC112)	MAIN 310
58	CALL XTRP(V10,V58,0.,FIG5)	MAIN 311
	CALL XTRP(V11,V59,0.,RCRTC)	MAIN 312
	V60=AMAX1(V59,V58)	MAIN 313
	A = F3(V60)	MAIN 314
	IF (NT.NE.1) GO TO 64	MAIN 315
	IF (V7.GE.F3(V60)) GO TO 64	MAIN 316
	V60 = F4(V60,V7)	MAIN 317
64	V64 = V9*V60	MAIN 318
	GO TO 153	MAIN 319
66	IF (ICODE(9).EQ.3) GO TO 67	MAIN 320
	CALL XTRP (V3,V9,0.,IDC094)	MAIN 321
67	IF (ICODE(10).GE.2)GO TO 94	MAIN 322
	IF (ICODE(11).GE.2)GO TO 79	MAIN 323
	CALL XTRP (V10,V68,0.,FIG5)	MAIN 324
	CALL XTRP (V11,V69,0.,RCRTC)	MAIN 325
	V70=AMAX1(V68,V69)	MAIN 326
	V60=V70	MAIN 327
	A = F3(V70)	MAIN 328
	IF(NT.NE.1) GO TO 76	MAIN 329
	IF (V7.GE. F3(V70)) GO TO 76	MAIN 330
	V70=F4(V70,V7)	MAIN 331
	V60=V70	MAIN 332
76	V76=V9/V70	MAIN 333
	V64=V9	MAIN 334
	V9=V76	MAIN 335
	GO TO 153	MAIN 336
79	V79=V9	MAIN 337
	KONV=0	MAIN 338
80	CALL XTRP(V79,V11,0.,IDC112)	MAIN 339
	CALL XTRP(V11,V81,0.,RCRTC)	MAIN 340
	V82=V79*V81	MAIN 341
	CAL ITRATI (V79,(V9-V82)/V9,0.0, AM, 30,-70,3,KONV)	MAIN 342
	IF (<ONV-2) 8C,84,2003	MAIN 343

***CONTINUING

84	CALL XTRP(V10,V84,0.0,FIG5)	MAIN 344
	V85= AMAX1(V81,V84)	MAIN 345
	V60= V85	MAIN 346
	A = F3(V85)	MAIN 347
	IF(VT .NE. 1) GO TO 91	MAIN 348
	IF(V7 .GE.F3(V85))GO TO 91	MAIN 349
	V85= F4(V85,V7)	MAIN 350
	V60= V85	MAIN 351
91	V91= V9/V85	MAIN 352
	V64= V9	MAIN 353
	V9= V91	MAIN 354
	GO TO 153	MAIN 355
94	IF(ICODE(11) .GE. 2) GO TO 112	MAIN 356
	KJNV=0	MAIN 357
	V96=V9	MAIN 358
97	CALL XTRP(V96,V10,0.0,IDC102)	MAIN 359
	CALL XTRP(V10,V98,0.0,FIG5)	MAIN 360
	V99= V96*V98	MAIN 361
	CAL ITRATI (V96,(V9-V99)/V9,0.,AM,30,-70,3,KONV)	MAIN 362
	IF (<ONV-2) 97,101,2004	MAIN 363
101	CALL XTRP(V11,V101,0.0,RCRTCD)	MAIN 364
	V102= AMAX1(V98,V101)	MAIN 365
	V60= V102	MAIN 366
	A = F3(V102)	MAIN 367
	IF(VT.NE. 1) GO TO 108	MAIN 368
	IF(V7 .GE.F3(V102))GO TO 108	MAIN 369
	V102= F4(V102,V7)	MAIN 370
	V60= V102	MAIN 371
108	V108= V9/V102	MAIN 372
	V64= V9	MAIN 373
	V9= V108	MAIN 374
	GO TO 153	MAIN 375
112	V112=V9	MAIN 376
	KJNV=0	MAIN 377
113	CALL XTRP(V112,V10,0.0,IDC102)	MAIN 378
	CAL XTRP(V10,V114,0.0,FIG5)	MAIN 379
	CAL XTRP(V112,V11,0.0,IDC112)	MAIN 380
	CALL XTRP(V11,V116,0.0,RCRTCD)	MAIN 381
	V117= AMAX1(V114,V116)	MAIN 382
	A = F3(V117)	MAIN 383
	IF(VT .NE. 1) GO TO 121	MAIN 384
	IF(V7 .GE.F3(V117))GO TO 121	MAIN 385
	V117= F4(V117,V7)	MAIN 386
121	V121= V112*V117	MAIN 387
	CALL ITRATI (V112,(V9-V121)/V9,0.,AM,30,-70,3,KONV)	MAIN 388
	IF (<ONV-2) 113,123,2005	MAIN 389
123	V60= V117	MAIN 390
	V64= V9	MAIN 391
	V9= V112	MAIN 392
	GO TO 153	MAIN 393
127	IF (ICODE(9).GE.3) GO TO 136	MAIN 394
	IF (ICODE(9).LE.1) GO TO 130	MAIN 395
	CAL XTRP (V3,V9,0.,IDC092)	MAIN 396
130	IF (ICODE(11).LE.1) GO TO 132	MAIN 397
	CALL XTRP (V9,V11,0.,IDC112)	MAIN 398
132	CALL XTRP (V11,V132,0.,FG2181)	MAIN 399
	V60=V132	MAIN 400

V64= V9*V132	MAIN 401
GJ TJ 153	MAIN 402
136 IF (ICODE(9).EQ.3) GO TO 138	MAIN 403
CALL XTRP (V3,V9,0.,IDC094)	MAIN 404
138 IF (ICODE(11).LE.1) GO TO 148	MAIN 405
V139=V9	MAIN 406
KONV=0	MAIN 407
139 CALL XTRP (V139,V11,0.,IDC112)	MAIN 408
CALL XTRP (V11,V141,0.,FG2181)	MAIN 409
V142=V139*V141	MAIN 410
CALL ITRATI (V139,(V9-V142)/V9,0.,AM,30,-70,3,KONV)	MAIN 411
IF (KONV-2) 139,144,2005	MAIN 412
144 V60=V141	MAIN 413
V64=V9	MAIN 414
V9=V139	MAIN 415
GJ TJ 153	MAIN 416
148 CALL XTRP (V11,V148,0.,FG2181)	MAIN 417
V149=V9/V148	MAIN 418
V60=V148	MAIN 419
V64=V9	MAIN 420
V9=V149	MAIN 421
153 IF (ICODE(12).GE.4) GO TO 157	MAIN 422
IF (ICODE(12).LE.2) GO TO 158	MAIN 423
CALL XTRP (V9,V12,0.,IDC123)	MAIN 424
GJ TJ 158	MAIN 425
157 V12= AEATMN	MAIN 426
158 IF(V12.NE.1. AND. (NT.LE.1 .OR. NT.EQ.4))GO TO 2008	MAIN 427
V158= V12*V9	MAIN 428
IF(ICODE(13).LE.1) GO TO 161	MAIN 429
CALL XTRP (V158,V13,0.,IDC132)	MAIN 430
161 IF (ICODE(14).LE.1) GO TO 163	MAIN 431
CALL XTRP (V158,V14,0.,IDC142)	MAIN 432
163 IF (ICODE(15).LE.1) GO TO 165	MAIN 433
CALL XTRP (V158,V15,0.,IDC152)	MAIN 434
165 IF(ICODE(16).LE.1) GO TO 167	MAIN 435
CALL XTRP (V158,V16,0.,IDC162)	MAIN 436
167 IF (NT.LT.4) GO TO 168	MAIN 437
IF (ICODE(22).LE. 1) GO TO 1671	MAIN 438
CALL XTRP(V9,V22,0.,IDC222)	MAIN 439
1671 AEP = V158/COS(ALPHAP*RAD)**2	MAIN 440
RPB = SQRT(APB/P1)	MAIN 441
LP = V22*DM	MAIN 442
RP = LP*TAN(ALPHAP*RAD)	MAIN 443
RPT = RP + RPB	MAIN 444
APT = P1*RPT**2	MAIN 445
V168 = AEP + APT + V13*V158	MAIN 446
GJ TJ 169	MAIN 447
168 V168=2.*(V158+V13*V158)	MAIN 448
169 IF (ICODE(17).LE.1) GO TO 171	MAIN 449
CALL XTRP (V168,V17,0.,IDC172)	MAIN 450
171 IF (ICODE(18).NE.2) GO TO 173	MAIN 451
CALL XTRP (V168,V18,0.,IDC182)	MAIN 452
173 IF (ICODE(19).LE.1) GO TO 175	MAIN 453
CALL XTRP (V168,V19,0.,IDC192)	MAIN 454
175 IF (ICODE(20).LE.1) GO TO 185	MAIN 455
IF (ICODE(20).GE.4) GO TO 183	MAIN 456
IF (ICODE(20).EQ.3) GO TO 180	MAIN 457

	CAL XTRP (V3,V20,0.,IDC202)	MAIN 458
	GJ TO 185	MAIN 459
180	V180 = V4*V3*SQRT(1.40*RRR*V5)*(V5+198.6)/(2.27E-8*(V5)**(1.5))/	MAIN 460
	1(RRR*V5)	MAIN 461
	CALL XTRP (V3,V20,V180,IDC203)	MAIN 462
	GJ TO 185	MAIN 463
183	TAW= V5*(1.+2*.89*V3**2)	MAIN 464
	TPRI = V5*(1.+0.035*V3**2+.45*(TAW/V5-1.))	MAIN 465
	LEFF = QIN(20,120)*DM	MAIN 466
	AMUP = 2.27E-8*TPRI **1.5/(TPRI+198.6)	MAIN 467
	RHO = GRAV*V4/(RRR*V5)	MAIN 468
	UFS = V3*SQRT(GAMFS*RRR*V5)	MAIN 469
	RHO = GRAV*V4/(RRR*TPRI)	MAIN 470
	REP = LEFF*RHO*UFS/(AMUP*GRAV)	MAIN 471
	AMU = 2.27E-8*V5 **1.5/(V5+198.6)	MAIN 472
	RETHET=AMUP/AMU*.044*REP /(ALOG10(REP)-1.5)**2	MAIN 473
	V20= GRAV*RETHET*AMU/(RHO*UFS*DM)	MAIN 474
185	IF(ICODE(21).LE.1) GO TO 187	MAIN 475
	CALL XTRP (V158,V21,0.,IDC212)	MAIN 476
187	IF (VT.LE.2) GO TO 204	MAIN 477
	IF (VT.GE.4) GO TO 204	MAIN 478
	IF (ICODE(22).LE.1) GO TO 191	MAIN 479
	CALL XTRP (V9,V22,0.,IDC222)	MAIN 480
191	IF (ICODE(23).GE.3) GO TO 196	MAIN 481
	QQQ=1.	MAIN 482
	IF (ICODE(23).LE.1) GO TO 195	MAIN 483
	CALL XTRP (V3,V23,0.,IDC232)	MAIN 484
195	GJ TO 199	MAIN 485
196	QQQ=2.	MAIN 486
	IF (ICODE(23).EQ.3) GO TO 199	MAIN 487
	CALL XTRP (V3,V23,0.,IDC234)	MAIN 488
199	IF (ICODE(24).LE.1) GO TO 204	MAIN 489
	CALL XTRP (V6,V24,0.,IDC242)	MAIN 490
204	AB = V13*V158	MAIN 491
	AWF = AWFAM*AM	MAIN 492
	LMB = LMBDM*DM	MAIN 493
	WSQWP1 = 0.	MAIN 494
	PTSPTP = 0.	MAIN 495
	IF(VT.NE.3)GAMS = V8	MAIN 496
	QMODEL = ICODE(6)	MAIN 497
	CDN = V60	MAIN 498
	NOZERR=0	MAIN 499
	IF(VT .LE. 2) CALL NOZZLE(V9,V64,V12,V8,V7,QMODEL,NT,FL,CDN,CT,	MAIN 500
	1 FLAG,NOZERR ,TID,CS,XMOM,CTID,A,XMEXIT)	MAIN 501
	IF(NOZERR .NE. 0.) GO TO 217	MAIN 502
	VDD = V12/V22	MAIN 503
	IF(VT. EQ. 3) CALL EJFCTR(V9*V22,V64,VDD,1./V22,V7,V23,QQQ,V8,GAMS	MAIN 504
	1,V24 ,CDN,CT,WSQWP1,PTSPTP,FLAG,NOZERR,LEXP,CTID,XMOM,QMODEL,	MAIN 505
	2 CS,TID,XMEXIT)	MAIN 506
	IF(NOZERR .NE. 0.) GO TO 217	MAIN 507
	IF(VT .GE.4) CALL NOZPLG(V9,V12,LP,ALPHAP,APB,V8,V7,CDN,CT,FLAG,	MAIN 508
	1 NOZERR,TID,CS,QMODEL ,V3,CTID,XMOM,ATMIN,ATMAX,XMEXIT)	MAIN 509
	IF(NOZERR .NE. 0.) GO TO 217	MAIN 510
	QFS=GAMFS/2.*V4*V3**2	MAIN 511
	AMB = AMBAM*AM	MAIN 512
	CALL AFTEND(V3,QFS,V4,V5,	MAIN 513
2	V64,V158,AB,NT,V8,V7,AMB ,AM,LMBDM,ISD,IT,	MAIN 514

***CONTINJING

1	IMSF,V18,V15,V16,V14,V20,AWFAM,V21,AWING,V19,V17,	MAIN	515
3	DBTP,DBTF,DB,DT,	MAIN	516
2	CDBTP,CDBTF,CDB,CJT,CTMTD,AFTERR,CTID,XMOM,V9,TID,CT,TMD,IMST,	MAIN	517
5	ATMIN,ATMAX,XMEXIT,GAMS)	MAIN	518
	IF(AFTERR.NE.0.) GO TO 217	MAIN	519
	IF(ICODE(12).LE.3) GO TO 216	MAIN	520
	IF(FLAGQ.EQ.1.) GO TO 216	MAIN	521
	ITMD=ITMD+1	MAIN	522
	V209 = AMAX1(V209,TMD)	MAIN	523
	IF(V209.EQ.TMD) V210 = V12	MAIN	524
	IF(ITMD.GT.21) GO TO 214	MAIN	525
	V12=V12+DAEAT	MAIN	526
	GO TO 158	MAIN	527
214	V12=V210	MAIN	528
	FLAGQ=1.	MAIN	529
	GO TO 158	MAIN	530
2000	WRITE(6,2500)	MAIN	531
2500	FORMAT(*0DIMENSIONAL FLIGHT SPEED INPUT REQUIRES AMBIENT PRESSURE	MAIN	532
	AND TEMPERATURE INPUTS*)	MAIN	533
	GO TO 217	MAIN	534
2001	WRITE(6,2501)	MAIN	535
2501	FORMAT(*NON-STANDARD TEMPERATURE INCREMENT MAY BE USED ONLY WITH	MAIN	536
	IN ALTITUDE INPUT FOR PRESSURE*)	MAIN	537
	GO TO 217	MAIN	538
2003	WRITE(6,2503)	MAIN	539
2503	FORMAT(*OAT=V79 WILL NOT CONVERGE*)	MAIN	540
	GO TO 217	MAIN	541
2004	WRITE(6,2504)	MAIN	542
2504	FORMAT(*OAT=V96 WILL NOT CONVERGE*)	MAIN	543
	GO TO 217	MAIN	544
2005	WRITE(6,2505)	MAIN	545
2505	FORMAT(*OAT=V112 WILL NOT CONVERGE*)	MAIN	546
	GO TO 217	MAIN	547
2007	WRITE(6,2507)	MAIN	548
2507	FORMAT(*INPUT TEMPERATURE ITERATION WILL NOT CONVERGE*)	MAIN	549
	GO TO 217	MAIN	550
2008	WRITE(6,2508)	MAIN	551
2508	FORMAT(*0 NON-UNITY DIVERGENCE AREA INPUT FOR NON-DIVERGING NOZ	MAIN	552
	LE*)	MAIN	553
	GO TO 217	MAIN	554
C	PUT OUT CASE ANSWERS	MAIN	555
216	IF(LPRINT.NE.2) GO TO 2160	MAIN	556
	WRITE(6,3999)	MAIN	557
	LPRINT = 0	MAIN	558
	WRITE(6,3998) TITLE	MAIN	559
	GO TO 2161	MAIN	560
2160	WRITE(6,4000) TITLE	MAIN	561
2161	AF = AM-V168	MAIN	562
	AFMET = AMB-V168	MAIN	563
	IFLAG=FLAG	MAIN	564
	ISDX=100	MAIN	565
	IF(ISD.EQ.4) ISDX=109	MAIN	566
	WRITE(6,4001) (DO3(ISD*9-9+L),L=1,9),(DO8(IT*9+27+L),L=1,9),	MAIN	567
	1 (DO8(NT*9+45+L),L=1,9),(DO8(ISDX-1+L),L=1,9),(DO8(ICODE(6)*9+108+L),L=1,9)	MAIN	568
	WRITE(6,4002)	MAIN	569
	WRITE(6,4003) V3,AWING,(DO82(IFLAG*9+L-9),L=1,7) ,DBTP ,V4,AM,	MAIN	570
		MAIN	571

***CONTINUING

1 V9,DBTF ,V5,AMB,V64,DB ,LMB,V158,DT ,AWF,V8	MAIN 572
WRITE(6,4004) V6,CS,CDBTP ,V7,CDN,CDBTF ,CT,AB,WSOWP1,CDB,	MAIN 573
1 CT4TD,AF,PTSP TP,CJT ,AFMET,V18 ,IMST	MAIN 574
IF(V3 .LT. 1.) WRITE(6,4005)(DOB1(J),J=1,4)	MAIN 575
IF(V3 .GE. 1.) WRITE(6,4005)(DOB1(J),J=5,8)	MAIN 576
LPRINT = LPRINT + 1	MAIN 577
217 CONTINUE	MAIN 578
3024 CONTINUE	MAIN 579
3023 CONTINUE	MAIN 580
3022 CONTINUE	MAIN 581
3021 CONTINUE	MAIN 582
3020 CONTINUE	MAIN 583
3019 CONTINUE	MAIN 584
3018 CONTINUE	MAIN 585
3017 CONTINUE	MAIN 586
3016 CONTINUE	MAIN 587
3015 CONTINUE	MAIN 588
3014 CONTINUE	MAIN 589
3013 CONTINUE	MAIN 590
3012 CONTINUE	MAIN 591
3011 CONTINUE	MAIN 592
3010 CONTINUE	MAIN 593
3009 CONTINUE	MAIN 594
3008 CONTINUE	MAIN 595
3007 CONTINUE	MAIN 596
3006 CONTINUE	MAIN 597
3005 CONTINUE	MAIN 598
3004 CONTINUE	MAIN 599
3003 CONTINUE	MAIN 600
READ(10,1010)IND,IVARY	MAIN 601
IF(IND.EQ.999)STOP	MAIN 602
DO 3025 I =1,22	MAIN 603
3025 NVARY(I) = 0	MAIN 604
IF(IND .EQ. 88)GO TO 6	MAIN 605
IF(IND .EQ. 99)GO TO 5	MAIN 606
IVARY = 19	MAIN 607
GO TO 5	MAIN 608
9999 STOP	MAIN 609
1000 FJR4AT(18A4)	MAIN 610
1010 FJR4AT(3I3,6F6.0)	MAIN 611
1015 FJR4AT(3I3,10F6.0)	MAIN 612
1020 FJR4AT(4F6.0)	MAIN 613
1030 FJR4AT(12F6.0)	MAIN 614
1040 FJR4AT(6X,22I3)	MAIN 615
3998 FJR4AT (1H ,T21,18A4)	MAIN 616
3999 FJR4AT (1H1)	MAIN 617
4000 FJR4AT (1H0,/,/,T21,18A4)	MAIN 618
4001 FJR4AT (1H0, T10, *CONFIGURATION*, /,T13, 5(9A4,/,T13))	MAIN 619
4002 FJR4AT (1H0, T10, *FLIGHT CONDITIONS*, T37, *FIXED AIRFRAME*,	MAIN 620
1 T65, *NOZZLE PARAMETERS*,T96, *AFT-END DRAG*	MAIN 621
4003 FJR4AT (1H , T10, *MACH NO*,8X, F7.4,5X,*WING AREA*, 7X, F7.2,5X,	MAIN 622
1 7A4, 3X, *DBT PRESS*,6X, F7.1,/,1H , T10,*P AMB,PSF*,6X, F7.1,	MAIN 623
2 5X, *MAX AREA*, 8X, F7.3, 5X, *THROAT GEOM AREA*, 3X, F7.4, 5X,	MAIN 624
3 *DBT FRICT*, 6X, F7.1,/,14 ,T10,*T AMB,R*, 8X,F7.1,5X,*M.B.AREA*,MAIN	625
4 8X,F7.3, 5X, *THRJAT FLOW AREA*, 3X, F7.4, 5X, *D BASE*,9X,F7.1,/MAIN	626
5 1H ,T37, *INIT.BT.LENGTH*, 2X,F7.3, 5X, *EXIT AREA*,10X,F7.4,5X, MAIN	627
6 *D TOTAL*, 8X,F7.1,/,1H , T10, *PERFORMANCE*, 15X, *INIT.BT AWET*MAIN	628

***CONTINJING

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7 , 4X,F7.3, 5X,*GAMMA*,14X,F7.4 ) MAIN 629
4004 FJR4AT (1H ,T1C, *PS*,13X,F7.4, T65,*CS*,17X, F7.4,5X,*CDBT PRESS*MAIN 630
1 , 4X, F8.5,/ ,1H ,T10,*PTJ/PAMB*,7X,F7.4,5X,*VARIABLE AIRFRAME*, MAIN 631
2 11X, *CDN*, 16X, F7.4, 5X, *CDBT FRICT*,4X,F8.5,/ ,1H ,T10, *CT*, MAIN 632
3 13X, F7.4, 5X,*BASE AREA*, 7X,F7.3,5X, *WSWP*, 15X, F7.4,5X, MAIN 633
4 *CD BASE*, 7X,F8.5,/ ,1H ,T10,*C(T-DT)*,8X,F7.4, 5X,*TOTAL A FRONTMAIN 634
5AL*,1X,F7.3,5X,*PTS/PTP*,12X, F7.4,5X, *CD TOTAL*,6X,F8.5,/ ,1H , MAIN 635
6 T37, *METRIC A FRJNTAL*,F7.3,/ ,1H ,T37,*IMSA*,12X, F7.4,/ ,1H , MAIN 636
7 T37, *IMST*, 12X,F7.4 ) MAIN 637
4005 FJR4AT(1H0, T1C, *ALL DRAGS FOR TWO NOZZLES*,/ ,1H , T10, *DRAG COEMAIN 638
1FFICIENTS REFERENCED TO WING AREA*, / ,1H , T10, *DRAGS ARE FOR AFTMAIN 639
2-END AFT OF *,4A4, / , 1H , T10, *ALL AREAS ARE IN SQUAKE FEET* ) MAIN 640
END MAIN 641

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***END

***BEGIN

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SUBROUTINE AREAS(PTPOP,PTSPTP,GAM,WSOWP1)
CJMN /AREA/GAMM,GAMMS,GAMS,APOAT,ASOAT,QMP,QMS
PTSJP = PTPUP*PTSPTP
QMP = SQRT(2./GAMM*(PTPOP**((GAMM/GAM)-1.))
QMS = SQRT(2./GAMMS*(PTSJP**((GAMMS/GAMS)-1.))
BP = 1. + GAMM/2.*QMP**2
BS = 1. + GAMMS/2.*QMS
APOAT = 1./(WSOWP1*SQRT(BP/BS)*QMP/QMS+1.)
ASOAT = 1. - APOAT
RETURN
END
```

AREAS000
AREAS005
AREAS010
AREAS015
AREAS020
AREAS025
AREAS030
AREAS035
AREAS040
AREAS045
AREAS050

***END

***BEGIN

```
SUBROUTINE ATM02(ALT,DELT,TAM,PAM,ERR)
ERR = 0
ALTKM = ALT*304.8E-6
IF(ALTKM .GT. 11.)GO TO 10
TAM = 288.15 - 6.5*ALTKM
PAM = 2116.22*((288.15-6.5*ALTKM)/288.15)**5.255876
GO TO 40
10 IF (ALTKM .GT. 20.) GO TO 20
TAM = 216.65
PAM = 472.685*EXP(-.157688*(ALTKM-11.))
GO TO 40
20 IF (ALTKM .GT. 32.) GO TO 30
TAM = 216.65 + (ALTKM-20.)
PAM = 114.345*(216.65/TAM)**34.1632
GO TO 40
30 IF (ALTKM .GT. 47.) GO TO 60
TAM = 228.65 + 2.8*(ALTKM-32.)
PAM = 18.129 * (228.65/TAM)**12.20111
40 TAM = (TAM*1.8) + DELT
50 RETURN
60 WRITE(6,1000)
GO TO 50
1000 FORMAT(1H0,*ATMO ROUTINE LIMITS EXCEEDED* )
END
```

ATMO2000
ATMO2001
ATMO2002
ATMO2003
ATMO2004
ATMO2005
ATMO2006
ATMO2007
ATMO2008
ATMO2009
ATMO2010
ATMO2011
ATMO2012
ATMO2013
ATMO2014
ATMO2015
ATMO2016
ATMO2017
ATMO2018
ATMO2019
ATMO2020
ATMO2021
ATMO2022
ATMO2023

***END

***BEGIN

SUBROUTINE AFTEND(MO,Q,PO,TO,AJCD,AE,AB,NT,GAM,PT PFS,AMB ,AM,	AFTEN000
1 LMBDM,ISD,IT,IMSF,IMSA,THE TAE,THETAM,DELXDM,THETDM,AWFAM,AWTAM,	AFTEN001
2 AWING,DELAAM,LDM,DB TP,DBTF,DB,DT,CDBTP,CDBTF,CDB,CDT,CTMTD,	AFTEN002
3 AFTERR ,CT ,XMOD,AT,TID,CV,TMD,IMST,ATMIN,ATMAX,ME,GAMS)	AFTEN003
DIMENSION K2M01(40) , K2M02(40) , K6IMST(149) , K3THET(26)	AFTEN004
DIMENSION K4IMS1(101) , K4IMS2(95) , K4IMS3(101)	AFTEN005
DIMENSION K4IMS4(107) , K4IMS5(95) , K4IMS6(30)	AFTEN006
DIMENSION K5THM1(125) , K5THM2(93) , K5THM3(109)	AFTEN007
DIMENSION K1CVL1(93),K1CVS1(93)	AFTEN008
DIMENSION K1CV(69)	AFTEN009
DIMENSION K1CVL2(71) , K1CVS2(93)	AFTEN010
DIMENSION K1CVL3(71) , K1CVS3(93)	AFTEN011
REAL MO,IMST1,LDM,IMSF,IMSA,IMST,ME,K1CV,K1CVS1,K1CVL1	AFTEN012
REAL K1CVS2,K1CVL2,K1CVS3,K1CVL3,K2M01,K2M02,K3THET	AFTEN013
REAL K4IMS1,K4IMS2,K4IMS3,K4IMS4,K4IMS5,K4IMS6	AFTEN014
REAL K5THM1,K5THM2,K5THM3,K6IMST	AFTEN015
REAL LMB,LMBDM,LL,MU,MUP,LEFF,LVAR,LT	AFTEN016
DATA K1CV / 5., 1., 0., 16., 4.,	AFTEN017
A 14., 0., 0., 0., .002, -.00075,.004, -.0013,	AFTEN018
B .006, -.0018, .008, -.0022, .01, -.0025,.012, -.0027,	AFTEN019
C 14., .6, 0., 0., .002, -.00075,.004, -.0013,	AFTEN020
D .006, -.0018,.008, -.0022,.01, -.0025,.012, -.0027,	AFTEN021
E 14., .8, 0., 0., .002, -.0014, .004, -.0024,	AFTEN022
F .006, -.003, .008, -.00335,.01, -.00355,.012, -.0036,	AFTEN023
G 14., .9, 0., 0., .002, -.0014, .004, -.0024,	AFTEN024
H .006, -.0032,.008, -.0039,.01, -.0044,.012, -.0048/	AFTEN025
DATA K1CVL1 / 5., 1., 0., 22., 4.,	AFTEN026
A 20., 0., 0., 0., .002, .0008, .004, .0016,	AFTEN027
B .006, .0022, .008, .0022, .01, .0019, .014, .0012,	AFTEN028
C .018, .0007, .022, .0002, .03, -.0006,	AFTEN029
D 20., .6, 0., 0., .002, .0008, .004, .0016,	AFTEN030
E .006, .0022, .008, .0022, .01, .0019, .014, .0012,	AFTEN031
F .018, .0007, .022, .0002, .03, -.0006,	AFTEN032
G 20., .8, 0., 0., .002, .0014, .004, .0027,	AFTEN033
H .006, .0035, .008, .0038, .01, .0033, .014, .0022,	AFTEN034
I .018, .0013, .024, .0001, .03, -.0008,	AFTEN035
J 20., .9, 0., 0., .002, .0018, .004, .0034,	AFTEN036
K .006, .0045, .008, .0049, .01, .0043, .014, .0028,	AFTEN037
L .018, .0016, .024, .0001, .03, -.0012 /	AFTEN038
DATA K1CVS1 / 5., 1., 0., 22., 4.,	AFTEN039
A 20., 0., 0., 0., .004, -.0005,.008, -.0015,	AFTEN040
B .012, -.0025,.016, -.0031,.02, -.0035,.022, -.0037,	AFTEN041
C .024, -.0038,.026, -.0039,.028, -.004,	AFTEN042
D 20., .6, 0., 0., .004, -.0005,.008, -.0015,	AFTEN043
E .012, -.0025,.016, -.0031,.02, -.0035,.022, -.0037,	AFTEN044
F .024, -.0038,.026, -.0039,.028, -.004,	AFTEN045
G 20., .8, 0., 0., .004, -.0003, .008, -.001,	AFTEN046
H .012, -.0024,.016, -.0038,.02, -.0047, .024, -.0054,	AFTEN047
I .028, -.0061,.032, -.0068,.036, -.0074,	AFTEN048
J 20., .9, 0., 0., .004, .0002, .008, -.0002,	AFTEN049
K .012, -.0024,.016, -.0042,.02, -.0054, .024, -.0064,	AFTEN050
L .028, -.0074,.032, -.0084,.039, -.01 /	AFTEN051
DATA K1CVL2 / 5., 1., 0., 22., 3.,	AFTEN052
A 20., 0., 0., 0., .002, -.0002,.004, -.0004,	AFTEN053

***CONTINJING

R	.006,	-.0007,.008,	-.001,.01,	-.0012,.014,	-.0017,	AFTEN054
C	.018,	-.0022,.022,	-.0026,.025,	-.0029,		AFTEN055
D	20.,	.6, 0.,	0., .002,	-.0002,.004,	-.0004,	AFTEN056
E	.006,	-.0007,.008,	-.001,.01,	-.0012,.014,	-.0017,	AFTEN057
F	.018,	-.0022,.022,	-.0026,.025,	-.0029,		AFTEN058
G	20.,	.9, 0.,	0., .004,	-.0017,.008,	-.0037,	AFTEN059
H	.012,	-.0053,.016,	-.0065,.02,	-.0076,.024,	-.0086,	AFTEN060
I	.028,	-.0096,.032,	-.0104,.036,	-.0112 /		AFTEN061
DATA K1CVS2 /	5.,	1.,	0., 22.,	4.,		AFTEN062
A	20.,	0., 0.,	0., .004,	-.0001,.008,	-.0007,	AFTEN063
B	.012,	-.0012,.016,	-.0016,.02,	-.002,.022,	-.0022,	AFTEN064
C	.024,	-.0024,.026,	-.0026,.028,	-.0028,		AFTEN065
D	20.,	.6, 0.,	0., .004,	-.0001,.008,	-.0007,	AFTEN066
E	.012,	-.0012,.016,	-.0016,.02,	-.002,.022,	-.0022,	AFTEN067
F	.024,	-.0024,.026,	-.0026,.028,	-.0028,		AFTEN068
G	20.,	.8, 0.,	0., .002,	.0001,.004,	.0002,	AFTEN069
H	.006,	0., .008,	-.0006,.012,	-.0019,.016,	-.0028,	AFTEN070
I	.02,	-.0036,.024,	-.0043,.028,	-.0049,		AFTEN071
J	20.,	.9, 0.,	0., .002,	0., .004,	0.,	AFTEN072
K	.006,	-.0003,.008,	-.0009,.012,	-.0023,.016,	-.0035,	AFTEN073
L	.02,	-.0045,.024,	-.0054,.028,	-.0063 /		AFTEN074
DATA K1CVL3 /	5.,	1.,	0., 22.,	3.,		AFTEN075
A	20.,	0., 0.,	0., .004,	-.0002,.008,	-.0005,	AFTEN076
B	.012,	-.0008,.016,	-.001,.02,	-.0013,.022,	-.0015,	AFTEN077
C	.024,	-.0016,.026,	-.0018,.028,	-.0019,		AFTEN078
D	20.,	.6, 0.,	0., .004,	-.0002,.008,	-.0005,	AFTEN079
E	.012,	-.0008,.016,	-.001,.02,	-.0013,.022,	-.0015,	AFTEN080
F	.024,	-.0016,.026,	-.0018,.028,	-.0019,		AFTEN081
G	20.,	.9, 0.,	0., .004,	.0003,.006,	.0002,	AFTEN082
H	.008,	-.0007,.012,	-.0023,.016,	-.0035,.02,	-.0044,	AFTEN083
I	.026,	-.0053,.032,	-.006,.04,	-.0066 /		AFTEN084
DATA K1CVS3 /	5.,	1.,	0., 22.,	4.,		AFTEN085
A	20.,	0., 0.,	0., .002,	-.0001,.004,	-.0002,	AFTEN086
B	.006,	-.0004,.008,	-.0006,.012,	-.0011,.016,	-.0016,	AFTEN087
C	.02,	-.0021,.024,	-.0026,.028,	-.0030,		AFTEN088
D	20.,	.6, 0.,	0., .002,	-.0001,.004,	-.0002,	AFTEN089
E	.006,	-.0004,.008,	-.0006,.012,	-.0011,.016,	-.0016,	AFTEN090
F	.02,	-.0021,.024,	-.0026,.028,	-.0030,		AFTEN091
G	20.,	.8, 0.,	0., .002,	.0004,.004,	.0006,	AFTEN092
H	.006,	.0007,.008,	.0003,.012,	-.0008,.016,	-.0019,	AFTEN093
I	.02,	-.003,.024,	-.0041,.028,	-.0052,		AFTEN094
J	20.,	.9, 0.,	0., .002,	.0008,.004,	.0015,	AFTEN095
K	.006,	.0019,.008,	.0011,.012,	-.0005,.016,	-.0019,	AFTEN096
L	.02,	-.0032,.024,	-.0045,.028,	-.0057 /		AFTEN097
DATA K2M01 /	2.,	1.,	0., 36.,			AFTEN098
*	1.0,	1.1, 1.1,	1.1, 1.2,	1.1,		AFTEN099
A	1.2,	1.1, 1.3,	.982, 1.4,	.932, 1.5,	.86,	AFTEN100
B	1.6,	.85, 1.7,	.88, 1.8,	.936, 1.9,	.98,	AFTEN101
C	2.0,	1.0, 2.1,	1.0, 2.2,	1.0, 2.3,	1.0,	AFTEN102
D	2.4,	1.0, 2.5,	1.0, 2.6,	1.0 /		AFTEN103
DATA K2M02 /	2.,	1.,	0., 36.,			AFTEN104
*	1.0,	1.3621,1.1,	1.3621,1.2,	1.3621,		AFTEN105
A	1.2,	1.3621,1.3,	1.20, 1.4,	1.12, 1.5,	1.067,	AFTEN106
B	1.6,	1.0316,1.7,	1.012, 1.8,	1.00, 1.9,	1.0,	AFTEN107
C	2.0,	1.0, 2.1,	1.0, 2.2,	1.0, 2.3,	1.0,	AFTEN108
D	2.4,	1.0, 2.5,	1.0, 2.6,	1.0 /		AFTEN109
DATA K3THET /	2.,	1.,	0., 22.,			AFTEN110

***CONTINUING

A	0.,	0.,	2.,	.006,	4.,	.013,	6.,	.019,	AFTEN111
B	8.,	.026,	10.,	.0325,	12.,	.039,	14.,	.046,	AFTEN112
C	16.,	.054,	18.,	.065,	20.,	.08	/		AFTEN113
DATA K4IMS1 /	5.,	1.,	0.,	32.,	3.,				AFTEN114
A	16.,	.15,	-2.0,	.052,	-1.5,	.055,	-1.25,	.056,	AFTEN115
B	-1.0,	.059,	-.75,	.063,	-.5,	.068,	-.25,	.074,	AFTEN116
C	0.,	.080,	14*0.,						AFTEN117
D	16.,	.34,	-2.0,	.085,	-1.5,	.091,	-1.25,	.096,	AFTEN118
E	-1.0,	.102,	-.75,	.110,	-.5,	.121,	-.25,	.1375,	AFTEN119
F	0.,	.157,	14*0.,						AFTEN120
G	30.,	.47,	-2.0,	.10,	-1.5,	.112,	-1.25,	.12,	AFTEN121
H	-1.0,	.129,	-.75,	.14,	-.5,	.152,	-.25,	.17,	AFTEN122
I	0.,	.198,	.25,	.244,	.55,	.344,	.55,	.344,	AFTEN123
J	.75,	.291,	1.0,	.246,	1.25,	.216,	1.5,	.198	/ AFTEN124
DATA K4IMS2 /	5.,	1.,	0.,	30.,	3.,				AFTEN125
A	12.,	.13,	-1.8,	.041,	-1.5,	.040,	-1.0,	.043,	AFTEN126
B	-.75,	.044,	-.5,	.048,	-.3,	.051,	16*0.,		AFTEN127
C	12.,	.30,	-1.75,	.072,	-1.5,	.075,	-1.0,	.085,	AFTEN128
D	-.75,	.094,	-.5,	.105,	-.3,	.118,	16*0.,		AFTEN129
E	28.,	.41,	-1.7,	.08,	-1.5,	.083,	-1.0,	.095,	AFTEN130
F	-.75,	.103,	-.5,	.115,	-.25,	.144,	0.,	.212,	AFTEN131
G	.25,	.34,	.38,	.424,	.38,	.424,	.5,	.40,	AFTEN132
H	1.0,	.295,	1.25,	.26,	1.4,	.24	/		AFTEN133
DATA K4IMS3 /	5.,	1.,	0.,	32.,	3.,				AFTEN134
A	16.,	.12,	-1.75,	.038,	-1.5,	.037,	-1.25,	.037,	AFTEN135
B	-1.,	.038,	-.75,	.04,	-.5,	.043,	-.25,	.047,	AFTEN136
C	-.1,	.05,	14*0.,						AFTEN137
D	16.,	.26,	-1.75,	.061,	-1.5,	.061,	-1.25,	.063,	AFTEN138
E	-1.,	.065,	-.75,	.069,	-.5,	.073,	-.25,	.079,	AFTEN139
F	-.1,	.083,	14*0.,						AFTEN140
G	30.,	.39,	-1.75,	.069,	-1.5,	.073,	-1.25,	.077,	AFTEN141
H	-1.,	.083,	-.75,	.09,	-.5,	.098,	-.25,	.116,	AFTEN142
I	0.,	.18,	.25,	.275,	.47,	.393,	.47,	.393,	AFTEN143
J	.75,	.341,	1.,	.303,	1.25,	.27,	1.6,	.229	/ AFTEN144
DATA K4IMS4 /	5.,	1.,	0.,	34.,	3.,				AFTEN145
A	12.,	.15,	-1.75,	.075,	-1.5,	.076,	-1.0,	.08,	AFTEN146
B	-.75,	.084,	-.5,	.088,	-.3,	.092,	20*0.,		AFTEN147
C	12.,	.34,	-1.7,	.062,	-1.5,	.063,	-1.0,	.066,	AFTEN148
D	-.75,	.07,	-.5,	.074,	-.3,	.077,	20*0.,		AFTEN149
E	32.,	.47,	-1.7,	.04,	-1.5,	.04,	-1.0,	.045,	AFTEN150
F	-.5,	.052,	-.35,	.055,	-.35,	.055,	-.25,	.07,	AFTEN151
G	0.,	.115,	.25,	.177,	.5,	.256,	.6,	.289,	AFTEN152
H	.6,	.289,	.75,	.258,	1.0,	.214,	1.25,	.179,	AFTEN153
I	1.4,	.161	/						AFTEN154
DATA K4IMS5 /	5.,	1.,	0.,	30.,	3.,				AFTEN155
A	14.,	.116,	-1.65,	.045,	-1.5,	.045,	-1.25,	.047,	AFTEN156
B	-1.0,	.049,	-.75,	.052,	-.5,	.055,	-.22,	.061,	14*0., AFTEN157
C	14.,	.20,	-1.65,	.064,	-1.5,	.064,	-1.25,	.065,	AFTEN158
D	-1.0,	.068,	-.75,	.071,	-.5,	.075,	-.25,	.08,	14*0., AFTEN159
E	28.,	.38,	-1.78,	.1,	-1.5,	.103,	-1.25,	.106,	AFTEN160
F	-1.0,	.112,	-.75,	.119,	-.5,	.13,	-.25,	.149,	AFTEN161
G	0.,	.23,	.25,	.428,	.5,	.47,	.5,	.47,	AFTEN162
H	.75,	.394,	1.0,	.345,	1.32,	.308	/		AFTEN163
DATA K4IMS6 /	2.,	1.,	0.,	26.,					AFTEN164
A	-1.75,	.065,	-1.5,	.066,	-1.25,	.067,	-1.0,	.07,	AFTEN165
B	-.75,	.075,	-.5,	.088,	-.25,	.112,	0.,	.15,	AFTEN166
C	.25,	.215,	.48,	.3,	.48,	.3,	.75,	.25,	AFTEN167

D)	1.0,	.218	/						AFTEN 168
DATA K5THM1	/	5.,	1.,	0.,	30.,	4.,			AFTEN 169
A	28.,	0.,	0.,	-.008,	2.,	-.003,	4.,	.001,	AFTEN 170
B	6.,	.004,	8.,	.006,	10.,	.002,	12.,	-.018,	AFTEN 171
C	14.,	-.049,	16.,	-.085,	18.,	-.114,	20.,	-.125,	AFTEN 172
D	22.,	-.125,	24.,	-.122,	26.,	-.120,			AFTEN 173
E	28.,	.6,	0.,	-.008,	2.,	-.003,	4.,	.001,	AFTEN 174
F	6.,	.004,	8.,	.006,	10.,	.002,	12.,	-.018,	AFTEN 175
G	14.,	-.049,	16.,	-.085,	18.,	-.114,	20.,	-.125,	AFTEN 176
H	22.,	-.125,	24.,	-.122,	26.,	-.120,			AFTEN 177
I	28.,	.8,	0.,	-.026,	2.,	-.019,	4.,	-.014,	AFTEN 178
J	6.,	-.009,	8.,	-.006,	10.,	-.009,	12.,	-.037,	AFTEN 179
K	14.,	-.075,	16.,	-.113,	18.,	-.145,	20.,	-.158,	AFTEN 180
L	22.,	-.156,	24.,	-.152,	26.,	-.147,			AFTEN 181
M	28.,	.9,	0.,	-.026,	2.,	-.019,	4.,	-.014,	AFTEN 182
N	6.,	-.009,	8.,	-.006,	10.,	-.009,	12.,	-.037,	AFTEN 183
O	14.,	-.075,	16.,	-.113,	18.,	-.145,	20.,	-.158,	AFTEN 184
P	22.,	-.156,	24.,	-.152,	26.,	-.147		/	AFTEN 185
DATA K5THM2	/	5.,	1.,	0.,	22.,	4.,			AFTEN 186
A	20.,	0.,	2.,	-.017,	4.,	-.016,	6.,	-.016,	AFTEN 187
B	8.,	-.017,	10.,	-.02,	12.,	-.038,	14.,	-.067,	AFTEN 188
C	16.,	-.099,	18.,	-.127,	20.,	-.138,			AFTEN 189
D	20.,	.6,	2.,	-.017,	4.,	-.015,	6.,	-.016,	AFTEN 190
E	8.,	-.017,	10.,	-.02,	12.,	-.038,	14.,	-.067,	AFTEN 191
F	16.,	-.099,	18.,	-.127,	20.,	-.138,			AFTEN 192
G	20.,	.8,	2.,	-.027,	4.,	-.027,	6.,	-.027,	AFTEN 193
H	8.,	-.029,	10.,	-.034,	12.,	-.056,	14.,	-.087,	AFTEN 194
I	16.,	-.123,	18.,	-.155,	20.,	-.172,			AFTEN 195
J	20.,	.9,	2.,	-.022,	4.,	-.021,	6.,	-.021,	AFTEN 196
K	8.,	-.022,	10.,	-.026,	12.,	-.049,	14.,	-.087,	AFTEN 197
L	16.,	-.132,	18.,	-.17,	20.,	-.187		/	AFTEN 198
DATA K5THM3	/	5.,	1.,	0.,	26.,	4.,			AFTEN 199
A	24.,	0.,	2.,	-.027,	4.,	-.024,	6.,	-.022,	AFTEN 200
B	8.,	-.021,	10.,	-.026,	12.,	-.04,	14.,	-.059,	AFTEN 201
C	16.,	-.08,	18.,	-.1,	20.,	-.109,	22.,	-.108,	AFTEN 202
D	24.,	-.103,							AFTEN 203
E	24.,	.6,	2.,	-.027,	4.,	-.024,	6.,	-.022,	AFTEN 204
F	8.,	-.021,	10.,	-.026,	12.,	-.04,	14.,	-.059,	AFTEN 205
G	16.,	-.08,	18.,	-.1,	20.,	-.109,	22.,	-.108,	AFTEN 206
H	24.,	-.103,							AFTEN 207
I	24.,	.8,	2.,	-.052,	4.,	-.048,	6.,	-.046,	AFTEN 208
J	8.,	-.045,	10.,	-.048,	12.,	-.064,	14.,	-.087,	AFTEN 209
K	16.,	-.112,	18.,	-.136,	20.,	-.148,	22.,	-.146,	AFTEN 210
L	24.,	-.14,							AFTEN 211
M	24.,	.9,	2.,	-.056,	4.,	-.053,	6.,	-.05,	AFTEN 212
N	8.,	-.049,	10.,	-.054,	12.,	-.077,	14.,	-.104,	AFTEN 213
O	16.,	-.135,	18.,	-.165,	20.,	-.179,	22.,	-.177,	AFTEN 214
P	24.,	-.17		/					AFTEN 215
DATA K61MST	/	3.,	1.,	0.,	24.,	6.,			AFTEN 216
A	18.,	0.,	0.,	0.,	.1,	.01,	.2,	.031,	AFTEN 217
B	.3,	.06,	.4,	.093,	.5,	.128,	.6,	.166,	AFTEN 218
C	.7,	.205,	.8,	.246,	0.,	0.,	0.,	0.,	AFTEN 219
D	20.,	.2,	0.,	0.,	.1,	.012,	.2,	.037,	AFTEN 220
E	.3,	.069,	.4,	.105,	.5,	.146,	.6,	.188,	AFTEN 221
F	.7,	.23,	.8,	.273,	.9,	.317,	0.,	0.,	AFTEN 222
G	22.,	.4,	0.,	0.,	.1,	.016,	.2,	.045,	AFTEN 223
H	.3,	.079,	.4,	.119,	.5,	.162,	.6,	.205,	AFTEN 224

I	.7,	.248,	.8,	.29,	.9,	.333,	1.0,	.377,	AFTEN 225
J	22.,	.6,	0.,	0.,	.1,	.018,	.2,	.052,	AFTEN 226
K	.3,	.095,	.4,	.138,	.5,	.18,	.6,	.224,	AFTEN 227
L	.7,	.266,	.8,	.309,	.9,	.351,	1.0,	.394,	AFTEN 228
M	22.,	.8,	0.,	0.,	.1,	.03,	.2,	.07,	AFTEN 229
N	.3,	.112,	.4,	.153,	.5,	.196,	.6,	.24,	AFTEN 230
O	.7,	.283,	.8,	.325,	.9,	.364,	1.0,	.402,	AFTEN 231
P	22.,	1.0,	0.,	0.,	.1,	.048,	.2,	.098,	AFTEN 232
Q	.3,	.144,	.4,	.185,	.5,	.225,	.6,	.265,	AFTEN 233
R	.7,	.305,	.8,	.345,	.9,	.385,	.93,	.4	AFTEN 234
									AFTEN 235
	P1 = 3.1415927								AFTEN 236
	GAMFS = 1.4								AFTEN 237
	RRR = 1716.5								AFTEN 238
	GRAV = 32.174								AFTEN 239
	A2 = AE + AB								AFTEN 240
	DELA = DELAAM*AM								AFTEN 241
	ANF = AWFAM*AM								AFTEN 242
	AWT = AWTAM*AM								AFTEN 243
	AP = AF - DELA/2.								AFTEN 244
	GAMAV = (GAM + GAMS)/2.								AFTEN 245
	PEPE = XMOM/(GAMAV*AE*ME**2)								AFTEN 246
	DM = 2.*SQRT(AM/P1)								AFTEN 247
	DELX = DELXDM*DM								AFTEN 248
	AFTERR = 0.0								AFTEN 249
6	THETA = THETAM* .017453								AFTEN 250
	R4ZA = IMSA*(AMB/AM)**1.5								AFTEN 251
	IMST = (RMZA/AMB*(AM-2.0*(AP+AB)) + [MSF/AM*(AM-AMB)]*AM/(AM-2.*								AFTEN 252
	1 (AP+AB))								AFTEN 253
40	RMF = XMOM *2.0 / (1.4*AM*M0**2)								AFTEN 254
	IF(M0 .GT. 1.0) GO TO 60								AFTEN 255
	PBPE = (0.9+0.0167*RMF)/(0.94+0.06*(2.0*(AB+AE)/AM))								AFTEN 256
	DB = (1.0-PBPE)*P0*2.0*AB								AFTEN 257
	GO TO 62								AFTEN 258
60	TETE = (1.0+(GAM-1.0)/2.0)/(1.0+(GAM-1.0)/2.0*ME**2)								AFTEN 259
	DEQ = SQRT(2.0*AM/3.141592)								AFTEN 260
	PBPE = TETE*3.5/(.5+6.*(AB+AE)								AFTEN 261
	1 /AM)*(0.19+1.28*RMF/(1.0+RMF))+								AFTEN 262
	1 .047*(5.0-M0)*(2.0*DELX/DEQ+(DELX/DEQ)**2)								AFTEN 263
	DB = (1.0-PBPE)*P0*2.0*AB								AFTEN 264
62	IF(M0 .LE. 1.0) GO TO 100								AFTEN 265
	X = SQRT(M0**2-1.0)*IMST								AFTEN 266
	Z = 2.0*(AP+AB)/AM								AFTEN 267
	CAL. XTRP(X,RK6,Z,K6IMST)								AFTEN 268
	IF(1SD .LE. 3) CALL XTRP(M0,RK2,0.,K2M01)								AFTEN 269
	IF(1SD .GE. 4) CALL XTRP(M0,RK2,0.,K2M02)								AFTEN 270
	R<3 = 0.0								AFTEN 271
	IF(M0 .GE. 2.0) GO TO 75								AFTEN 272
	X1 = 0.0								AFTEN 273
	X3 = LDM*SQRT(4.0*AM/3.141592)								AFTEN 274
	Y1 = DEQ/2.0								AFTEN 275
	Y3 = SQRT((AE+AB)/3.141592)								AFTEN 276
	Y2 = Y3+(X3-X1)*TAN(THETA)								AFTEN 277
	XM1 = M0								AFTEN 278
	XM2 = M0								AFTEN 279
	XM3 = M0								AFTEN 280
	NV = 1								AFTEN 281
	ALPHA0 = ATAN(1.0/SQRT(XM2**2-1.0))								

	THE TAR = -THE TR / 2.0	AFTEN 282
65	ALPHA = ATAN(1.0/SQRT(XM3**2-1.0))	AFTEN 283
	ALPHAR = (ALPHA+ALPHA0)*0.5	AFTEN 284
	ALP = TAN(ALPHAC)-TAN(THE TAR-ALPHAR)	AFTEN 285
	BET = (Y3-Y1)/ALP	AFTEN 286
	CET = X1*TAN(ALPHA0)/ALP	AFTEN 287
	DET = X3*TAN(THE TAR-ALPHAR)/ALP	AFTEN 288
	XX2 = BET+CET-DET	AFTEN 289
	YY2 = (XX2-X1)*TAN(ALPHA0)+Y1	AFTEN 290
	Y2 = (YY2+Y3)/2.0	AFTEN 291
	T3TT = 1.0/(1.0+0.2*XM3**2)	AFTEN 292
	T2TT = 1.0/(1.0+0.2*XM2**2)	AFTEN 293
	T1TT = (T3TT+T2TT)/2.0	AFTEN 294
	ERQ = SQRT(T1TT/T3TT)/COS(ALPHAR)	AFTEN 295
	FRQ = TAN(THE TAR)*TAN(ALPHAR)	AFTEN 296
	GRQ = YR*(FRQ+1.0)	AFTEN 297
	XM4 = ERQ*(FRQ/GRQ*(X3-XX2)+THE TR)+XM2*SQRT(T2TT/T3TT)	AFTEN 298
	IF(ABS(XM4-XM3).LE. 0.0001*XM3)GO TO 70	AFTEN 299
	XM3 = XM4	AFTEN 300
	IF(XM4.LE. 1.01 .AND. NN.EQ. 1) XM3 = 1.2*MO	AFTEN 301
	IF(XM4.LE. 1.01 .AND. NN.GT. 1) GO TO 70	AFTEN 302
	NN = NN+1	AFTEN 303
	IF(NN.LE. 100) GO TO 65	AFTEN 304
	AFTERR = 1.0	AFTEN 305
	WRITE (6,9960)	AFTEN 306
	RETURN	AFTEN 307
70	XML = AMAX1(1.05,XM4)	AFTEN 308
	PLPE = ((1.0+0.2*MO**2)/(1.0+0.2*XML**2))**3.5	AFTEN 309
	QL = 0.7*PO*XML**2*PLPE	AFTEN 310
	IF((PEPE-PLPE)*PO/QL .GE. 1.4) CALL XTRP(THETAM,RK3,0.,K3THE T)	AFTEN 311
75	DBT = RK6/(MO**2-1.0)*Q*(AM-2.0*(AP+AB))*RK2-	AFTEN 312
1	2.0*RK3*AQ*(PEPE-PLPE)*PO	AFTEN 313
	GO TO 211	AFTEN 314
100	X = (MO**2-1.0)/((MO**2+MSA)**.6666667)	AFTEN 315
	X = AMAX1(X,-2.)	AFTEN 316
	Z = 2.0*(AP+AB)/AMB	AFTEN 317
	IF(VT.EQ.1 .AND. DELXDM .GT. 0.) GO TO 145	AFTEN 318
	IF(IT.EQ.1 .AND. ISD .EQ. 1) CALL XTRP(X,RK4,Z,K4IMS1)	AFTEN 319
	IF(IT.EQ.1 .AND. ISD .EQ. 2) CALL XTRP(X,RK4,Z,K4IMS2)	AFTEN 320
	IF(IT.EQ.1 .AND. ISD .EQ. 3) CALL XTRP(X,RK4,Z,K4IMS3)	AFTEN 321
	IF(IT.EQ.2 .AND. ISD .EQ. 1) CALL XTRP(X,RK4,Z,K4IMS4)	AFTEN 322
	IF(IT.EQ.1 .AND. ISD .EQ. 4) CALL XTRP(X,RK4,Z,K4IMS5)	AFTEN 323
	GO TO 148	AFTEN 324
145	CAL XTRP(X,RK4,Z,K4IMS6)	AFTEN 325
148	IF(ISD .EQ. 1) CALL XTRP(THETAE,RK5,MO,K5THM1)	AFTEN 326
	IF(ISD .EQ. 2) CALL XTRP(THETAE,RK5,MO,K5THM2)	AFTEN 327
	IF(ISD .GE. 3) CALL XTRP(THETAE,RK5,MO,K5THM3)	AFTEN 328
	FID = PTPFS*PO*AJCD* SQRT(2.0*GAM**2/(GAM-1.0)*(2.0/(GAM+1.0))**	AFTEN 329
1	((GAM+1.0)/(GAM-1.0))*(1.0-(1.0/PTPFS)**((GAM-1.0)/GAM)))	AFTEN 330
	RK1 = 0.0	AFTEN 331
	IF(CT.GT.1.)GO TO 210	AFTEN 332
	IF(VT .EQ. 1) GO TO 185	AFTEN 333
	IF(VT .LE. 3) CALL XTRP(1.-CT,RK1,MO,K1CV)	AFTEN 334
	IF(VT .LE. 3)GO TO 210	AFTEN 335
	IF(VT .GE. 4) CALL XTRP(1.-CT,RK1,MO,K1CVL3)	AFTEN 336
	IF(VT .GE. 4) CALL XTRP(1.-CT,RK5,MO,K1CVS3)	AFTEN 337
	GO TO 186	AFTEN 338

***CONTINUING

185	IF(DELXDM.EQ. C.) CALL XTRP(1.-CT,RKL,MO,KICVL2)	AFTEN 339
	IF(DELXDM.EQ. C.) CALL XTRP(1.-CT,RKS,MO,KICVS2)	AFTEN 340
	IF(DELXDM.GT. C.) CALL XTRP(1.-CT,RKL,MO,KICVL1)	AFTEN 341
	IF(DELXDM.GT. C.) CALL XTRP(1.-CT,RKS,MO,KICVS1)	AFTEN 342
186	RKL = RKS + (AT-ATMIN)*(RKL-RKS)/(ATMAX-ATMIN)	AFTEN 343
210	DBTP = RK4*((MSA/MO)**.6666667*Q*(AMB-2.0*(AP+AB))+RK5*Q*2.0*	AFTEN 344
	1 (AF+AB)+RKL*2.0*FID	AFTEN 345
211	LMB = LMBDM*DM	AFTEN 346
	LL = LDM*DM	AFTEN 347
	FTHETA = THETDM*DM	AFTEN 348
	RHO = PO*GRAV/(RRR*TO)	AFTEN 349
	MU = 2.27E-8*TO**((1.5)/(TO+198.6))	AFTEN 350
	UO = MO*SQR(T(GAMFS*RRR*TO))	AFTEN 351
	RETHET = RHO*U*(FTHETA/(GRAV*MU))	AFTEN 352
	TAW = TO*(1.+ .178*M0**2)	AFTEN 353
	TP = TO*(1. + .035*M0**2 + .45*(TAW/TO -1.))	AFTEN 354
	MUP = 2.27E-8*TP**((1.5)/(TP+198.6))	AFTEN 355
	KT = 0	AFTEN 356
	RETHP = 1.E6	AFTEN 357
215	FJNC = RETHET -MUP*.044*RETHP/(ALOG10(RETHP)-1.5)**2/MJ	AFTEN 358
	SAVRP = RETHP	AFTEN 359
	CALL ITRATE(RETHP,FUNC,0.,KT)	AFTEN 360
	IF(ABS(FUNC) .LT. 1.E+2) GO TO 225	AFTEN 361
	IF(SAVRP-RETHP .GT. 0.)RETHP = AMAX1(RETHP, .8*SAVRP)	AFTEN 362
	IF(SAVRP-RETHP .LT. 0.)RETHP = AMIN1(RETHP, 1.2*SAVRP)	AFTEN 363
	IF(KT.GT.99)GO TO 220	AFTEN 364
	IF(KT.EQ.1)RETHP = 1.01*RETHP	AFTEN 365
	GO TO 215	AFTEN 366
220	AFTERR = 1.	AFTEN 367
	WRITE(6,9970)	AFTEN 368
	RETURN	AFTEN 369
225	RHOP = PO*GRAV/(RRR*TP)	AFTEN 370
	LEFF = GRAV*MUP*RETHP/(RHOP*UO) + LMB	AFTEN 371
	LVAR = LL - LMB	AFTEN 372
	AWET = AWT - AWF	AFTEN 373
	LFLG = 1	AFTEN 374
230	LT = LEFF + LVAR	AFTEN 375
	RELP = RHOP*UO*LT/(GRAV*MUP)	AFTEN 376
	CF = (.088*(ALOG10(RELP) - 2.3686))*TO/(ALOG10(RELP)-1.5)**3 /TP	AFTEN 377
	DBTF = CF*Q*AWET	AFTEN 378
	IF(MO .LT. 1.) GO TO 250	AFTEN 379
	IF(LFLG .EQ. 2) GO TO 235	AFTEN 380
	LFLG = 2	AFTEN 381
	LEFF = LEFF - LMB	AFTEN 382
	LVAR = LMB	AFTEN 383
	AWET = AWF	AFTEN 384
	DBTF1 = DBTF	AFTEN 385
	GO TO 230	AFTEN 386
235	DBTF = (DBTF1 + DBTF)	AFTEN 387
250	DT = DBTP + DB + DBTF	AFTEN 388
	QAWING = Q*AWING	AFTEN 389
	COBTP = DBTP/QAWING	AFTEN 390
	COBTF = DBTF/QAWING	AFTEN 391
	CDB = DB/QAWING	AFTEN 392
	TMD = TID*PTPFS*PO*AJCD*CV - DT	AFTEN 393
	CTMD = TMD/((TID*PTPFS*PO*AJCD)	AFTEN 394
	COT = DT/QAWING	AFTEN 395

RETURN
9960 FJRMAT(* EXTERNAL EXIT MACH NUMBER ITERATION FAILED*)
9970 FJRMAT (*0 REYNOLDS NUMBER ITERATION FAILED*)
END

AFTEN396
AFTEN397
AFTEN398
AFTEN399

***END

***BEGIN

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SUBROUTINE EJECTR(AT,ATFLOW,AEOAT,APTOAT,ANPR,DUMVAR,QQQ,GAM,GAMS,EJECT001
1  RS2,CDN,CT,WSOWP1,PTSPTP,FLAG,NOZERR,FL,CTID,XMOM,QMODEL,  CS, EJECT002
2  TID,XMEXIT) EJECT003
  DIMENSION X(2),XMIN(2),XMAX(2),EPS(2),F(2) EJECT004
  DIMENSION FIG5(32),FIG11A(157),FIG11B(112),FIG11(269) EJECT005
  EQUIVALENCE (FIG11A(1),FIG11(1)),(FIG11B(1),FIG11(158)) EJECT006
  REAL MP,MEP,MS,MES,ME EJECT007
  COMMON /AREA/GAMM,GAMMS,GAMSP,APUAT,ASUAT,MP,MS EJECT008
  DATA FIG11A / 5., 1., 0., 24., 11., EJECT009
  A 14., 0., 1.025, .997, 1.1, .997, 1.2, .997, EJECT010
  B 1.3, .997, 1.4, .997, 1.5, .997, 1.56, .997, EJECT011
  C 0., 0., 0., 0., 0., 0., 0., 0., EJECT012
  D 14., 2., 1.025, .997, 1.1, .997, 1.2, .997, EJECT013
  E 1.2, .997, 1.25, .996, 1.3, .995, 1.3, .995, EJECT014
  F 0., 0., 0., 0., 0., 0., 0., 0., EJECT015
  G 20., 4., 1.025, .997, 1.1, .997, 1.2, .997, EJECT016
  H 1.3, .997, 1.33, .997, 1.33, .997, 1.4, .9965, EJECT017
  I 1.5, .996, 1.6, .9952, 1.63, .995, 0., 0., EJECT018
  J 22., 6., 1.025, .997, 1.1, .997, 1.2, .997, EJECT019
  K 1.4, .997, 1.5, .997, 1.56, .997, 1.56, .997, EJECT020
  L 1.6, .996, 1.7, .9945, 1.8, .993, 2.0, .9928, EJECT021
  M 22., 8., 1.025, .997, 1.06, .997, 1.06, .997, EJECT022
  N 1.1, .9955, 1.2, .9945, 1.3, .995, 1.4, .9955, EJECT023
  O 1.5, .996, 1.6, .9965, 1.8, .996, 2.0, .994, EJECT024
  P 22., 10., 1.025, .997, 1.045, .997, 1.045, .997, EJECT025
  Q 1.1, .993, 1.2, .991, 1.3, .991, 1.4, .9915, EJECT026
  R 1.5, .992, 1.6, .9925, 1.8, .9935, 2.0, .994, EJECT027
  S 22., 12., 1.025, .997, 1.032, .997, 1.032, .997/ EJECT028
  DATA FIG11B / EJECT029
  A 1.1, .9915, 1.2, .9875, 1.3, .986, 1.4, .9862, EJECT030
  B 1.5, .9865, 1.6, .9875, 1.8, .989, 2.0, .990, EJECT031
  C 22., 14., 1.025, .997, 1.032, .997, 1.032, .997, EJECT032
  D 1.1, .990, 1.2, .9835, 1.3, .9815, 1.4, .981, EJECT033
  E 1.5, .981, 1.6, .9812, 1.8, .982, 2.0, .9835, EJECT034
  F 22., 16., 1.025, .997, 1.025, .997, 1.1, .988, EJECT035
  G 1.2, .9815, 1.3, .978, 1.4, .976, 1.5, .975, EJECT036
  H 1.6, .9753, 1.7, .9756, 1.8, .976, 2.0, .977, EJECT037
  I 22., 18., 1.025, .997, 1.1, .986, 1.2, .978, EJECT038
  J 1.3, .973, 1.4, .971, 1.5, .969, 1.6, .968, EJECT039
  K 1.7, .968, 1.8, .968, 1.9, .9685, 2.0, .969, EJECT040
  L 22., 20., 1.025, .997, 1.1, .9845, 1.2, .976, EJECT041
  M 1.3, .970, 1.4, .966, 1.5, .963, 1.6, .9622, EJECT042
  N 1.7, .9618, 1.8, .9615, 1.9, .9612, 2.0, .9612 / EJECT043
  NOZERR=0 EJECT044
  CTID = 1. EJECT045
  GAMSP = GAMS EJECT046
  PI = 4.*ATAN(1.) EJECT047
  RAD = .0174533 EJECT048
  RS = 53.35 EJECT049
  RP = RS/RSRP EJECT050
  APT = APTOAT*AT EJECT051
  CDN = ATFLOW/APT EJECT052
  AE = AEOAT * AT EJECT053
  RE = SQRT(AE/PI) EJECT054

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***CONTINJING

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RT = SQRT(AT/PI)
THET = ATAN((RE-RT)/SQRT(FL-(RE-RT)**2))
THETA = THET / RAD
IF(DUMVAR.GT. 0.0) GO TO 3
PTSPTP= 1.0
WSDWP1= 0.0
FFIDS= 0.0
AEOAPS= AE/ATFLOW
G12GM1=(GAM+1.0)/(2.0*(GAM-1.0))
QMQ = 1.
KTE= 0
4 FJNC5 = AEOAPS-((2.+(GAM -1.)*QMQ**2)/(GAM +1.))*G12GM1/QMQ
SVQMQE = QMQ
CALL ITRATE(QMQ, FUNC5, 0., KTE)
IF (ABS(FUNC5) .LE. 1.E-4) GO TO 5
IF (KTE.GT. 25) GO TO 475
IF (KTE.EQ. 1) QMQ = 1.01
IF (SVQMQE - QMQ .GT. 0.1) QMQ = AMAX1(QMQ , .5*(1.+SVQMQE))
IF (SVQMQE - QMQ .LT. 0.1) QMQ = AMIN1(QMQ , 1.2*SVQMQE)
GO TO 4
5 PQPTT = (1. + .5* QMQ**2 *(GAM -1.))*(-GAM /(GAM -1.))
FSAAPS = PQPTT*AEOAPS*(1.+GAM *QMQ**2)
CALL XTRP(AEOAPS,CS,THETA,FIG11)
IF (QMODEL .GE.2.1) CS = CS-.007
FFID= GAM*SQRT(2./(GAM-1.)*(2./(GAM+1.))*((GAM+1.)/(GAM-1.))
1 *(1.-(1./ANPR))*((GAM-1.)/GAM))
FLAG = 4.
TID = FFID
X4EXIT = QMQ
CT = (CS*FSAAPS- AEOAPS/ANPR)/FFID
IF(PQPTT.GT. 1./ANPR)CTID= (FSAAPS-AEOAPS/ANPR)/FFID
X4J4= (PQPTT*AEOAPS*GAM*QMQ**2)*ANPR*ATFLOW
GO TO 500
3 IF(QQQ.EQ.2.) GO TO 2
PTSPTP=DUMVAR
IF(ANPR*PTSPTP .GE. 1.) GO TO 2
WRITE(6,1020)
GO TO 490
2 GAM2 = GAM + 1.
GAM4 = GAM - 1.
GAM5 = GAM5 + 1.
GAM6 = GAM5 - 1.
ZZ = 0.
AEOAPS = AEOAT/APTOAT/CDN
ATOAPS = 1./APTOAT/CDN
C*** WASWAP SECTION
IF(QQQ.EQ.1.) GO TO 19
WSDWP1=DUMVAR
WSDWP2=DUMVAR
KJNV=0
X(1) = .25
X(2) = .75
X4IN(1) = 0.
X4IN(2) = 0.
X4AX(1) = 1.
X4AX(2) = 1.
EPS(1) = 1.E-4

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EJECT055
EJECT056
EJECT057
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EJECT110
EJECT111

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10 EPS(2) = 1.E-4
PJPTP=X(1)
PJPTS=X(2)
PTSPTP=X(1)/X(2)
WSOWPA =ATJAPS*SQRT(2./GAMM*(GAMP/2.)*(GAMP/GAMM))-(1./POPTP)**(1.
1./GAM)/SQRT(1.-POPTP**((GAMM/GAM)))
F(1)=
1WSOWP1 = WSOWPA*SQRT(RP/RS*GAMS/GAM*GAMM/GAMMS*(1.-POPTS**((GAMMS/
1GAMS))) *PTSPTP*POPTS**((1./GAMS))
WSOWPB = GAMS/GAM*PTSPTP*(GAMM/2.*(POPTP**((1.-GAM)/GAM)-1.))*(-1.
1) - 1.) *PJPTS**((1./GAMS)*SQRT(2./RS*GAMS/GAMMS*(1.-POPTS**((GAMMS
2/GAMS))))
F(2)=
1WSOWP2 = WSOWPB/((1.-GAMMS/2.*(POPTS**((1.-GAMS)/GAMS)-1.))*(-1.
1)*PJPTP**((1./GAM)*SQRT(2./RP*GAM/GAMM*(1.-POPTP**((GAMM/GAM))))
CALL ITRATA(2, ,F,XMIN,XMAX,EPS,30,KONV)
IF(KONV - 2) 1C,11,485
PPOPTP=POPTP
IF(X(1).LT.0. .OR. X(2).LT.0.)GO TO 485
IF(ANPR*PTSPTP .GE. 1.) GO TO 46
WRITE(6,1020)
GO TO 490
19 KT = 0
PJPTP=PTSPTP*.75
PJPTS = PPOPTP/PTSPTP
20 PJPTS=PPOPTP/PTSPTP
WSOWP1 =ATJAPS*SQRT(2./GAMM*(GAMP/2.)*(GAMP/GAMM))-(1./POPTP)**(1.
1./GAM)/SQRT(1.-POPTP**((GAMM/GAM)))
WSOWP1 = WSOWP1*SQRT(RP/RS*GAMS/GAM*GAMM/GAMMS*(1.-POPTS**((GAMMS/
1GAMS))) *PTSPTP*POPTS**((1./GAMS))
WSOWP2 = GAMS/GAM*PTSPTP*(GAMM/2.*(POPTP**((1.-GAM)/GAM)-1.))*(-1.
1) - 1.) *PJPTS**((1./GAMS)*SQRT(2./RS*GAMS/GAMMS*(1.-POPTS**((GAMMS
2/GAMS))))
WSOWP2 = WSOWP2/((1.-GAMMS/2.*(POPTS**((1.-GAMS)/GAMS)-1.))*(-1.
1)*PJPTP**((1./GAM)*SQRT(2./RP*GAM/GAMM*(1.-POPTP**((GAMM/GAM))))
FUNKY = WSOWP1 - WSOWP2
SPOPTP = PPOPTP
CALL ITRATE(POPTP, FUNKY, 0., KT)
IF(ABS(FUNKY) .LT. .001) GO TO 40
IF(KT .GT. 25) GO TO 485
IF (SPOPTP - POPTP .GT. 0.) POPTP =AMAX1(POPTP, .8*SPOPTP)
IF (SPOPTP - POPTP .LT. 0.) POPTP =AMIN1(POPTP,.5*(SPOPTP+
1 PTSPTP))
IF(KT .EQ. 1) POPTP = 1.01* POPTP
GO TO 20
40 PPOPTP = PJPTP
WSOWP1 = .5*(WSOWP1+WSOWP2)
46 PJPTP = PPOPTP
WSOWP = WSOWP1
AEDA = AEDAPS
PJPTPX = PPOPTP
XX = 1.
BERN = 1
GO TO 200
47 PEOPTP = PPOPTPZ
PEOPTS = PJPTS
IF (PEOPTP .GE. 1./ANPR) GO TO 80

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	ZZ = 1.	EJECT 169
	IF (JQQ.EQ.1.) GO TO 48	EJECT 170
	WSOWPC = AEOAPS*SQRT(2./GAMM*(GAMP/2.)*(GAMP/GAMM))-(1./(1./ANPR)	EJECT 171
	1)*(1./GAM)/SQRT(1.-(1./ANPR)*(GAMM/GAM))	EJECT 172
	PTSPTP =	EJECT 173
	1WSOWP1 / WSOWPC*SQRT(RP/RS*GAMS/GAM*GAMM/GAMMS*(1.-POPTS*(GAMMS/	EJECT 174
	1 GAMS))) *POPTS*(1./GAMS)	EJECT 175
	IF (ANPR*PTSPTP .GE. 1.) GO TO 49	EJECT 176
	WRITE(6,1020)	EJECT 177
	GO TO 490	EJECT 178
48	WSOWPX = AEOAPS*SQRT(2./GAMM*(GAMP/2.)*(GAMP/GAMM))-(1./(1./ANPR)	EJECT 179
	1)*(1./GAM)/SQRT(1.-(1./ANPR)*(GAMM/GAM))	EJECT 180
	POPTS = 1./ANPR/PTSPTP	EJECT 181
	WSOWPX = WSOWPX*SQRT(RP/RS*GAMS/GAM*GAMM/GAMMS*(1.-POPTS*(GAMMS/	EJECT 182
	1 GAMS))) *PTSPTP*POPTS*(1./GAMS)	EJECT 183
	IF (WSOWPX.GT.WSOWP1) GO TO 480	EJECT 184
	WSOWP1=WSOWPX	EJECT 185
49	WSW = WSOWP1	EJECT 186
	AEOA = ATOAPS	EJECT 187
	BERN = 2	EJECT 188
	POPTPX = POPTPZ-.1	EJECT 189
	GO TO 200	EJECT 190
50	PTOPTP = POPTPZ	EJECT 191
	PTOPTS = POPTS	EJECT 192
80	IF (ZZ .EQ. 0.) CALL AREAS(1./POPTP,PTSPTP,GAM,WSOWP1)	EJECT 193
	IF (ZZ .NE. 0.) CALL AREAS(1./PTOPTP,PTSPTP,GAM,WSOWP1)	EJECT 194
	IF (PEOPTP .GT. 1./ANPR) GO TO 90	EJECT 195
	CALL AREAS(ANPR,PTSPTP,GAM,WSOWP1)	EJECT 196
	AEOAPS = APOAT*AEOAT*ATOAPS	EJECT 197
	AESAPS = ASOAT*AEOAT*ATOAPS	EJECT 198
	MEP = MP	EJECT 199
	MES = MS	EJECT 200
	X4EXIT = APOAT*MEP + ASOAT*MES	EJECT 201
	FFID = GAM*SQRT(2./GAMM*(2./GAMP)*(GAMP/GAMM))*(1.-(1./ANPR)*(EJECT 202
	1 GAMM/GAM)))	EJECT 203
	FFIDS = WSOWP1*SQRT(2.*GAM*GAMS/GAMMS*RS/RP*(2./GAMP)*(GAMP/GAMM)	EJECT 204
	1 * (1.-(1./ANPR*1./PTSPTP)*(GAMMS/GAMS)))	EJECT 205
	FFS = PEOPTP*AEOAPS*(1.+GAM*MEP**2)	EJECT 206
	FFSS = PEOPTS*PTSPTP*AESAPS*(1.+GAMS*MES**2)	EJECT 207
	TID = FFID + FFIDS	EJECT 208
	CS = .995	EJECT 209
	IF (JMODE1 .GE.2.) CS = CS-.007	EJECT 210
	CT = (CS * (FFS+FFSS)-AEOAT*ATOAPS/ANPR)/(FFID+FFIDS)	EJECT 211
	FLAG = 1.	EJECT 212
	X4JM = (PEOPTP*AEOAPS*GAM*MEP**2+ PEOPTS*PTSPTP*AESAPS*GAMS*MES**2	EJECT 213
	1)*ANPR*ATFLOW	EJECT 214
	GO TO 500	EJECT 215
90	PRCOPD = .63 + .04*ALOG(WSOWP1+.01)	EJECT 216
	PRCPTT = PRCOPD/ANPR	EJECT 217
	WSW = WSOWP1	EJECT 218
	BERN = 3	EJECT 219
	XX = 0.	EJECT 220
	AEOA = AEOAPS	EJECT 221
	POPTPX = PPOPTP-.001	EJECT 222
	GO TO 200	EJECT 223
92	PEOPTP = POPTPZ	EJECT 224
	PEOPTS = POPTS	EJECT 225

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IF (PRCPTT .LE. PEUPTP) GO TO 190
IF (PRCPTT .LE. PPJPTP) GO TO 95
WRITE (6,1010)
GO TO 490
95  PRCPTS = PRCPTT/PTSPTP
AIOAPS = WSOWP1/(SQRT(RP/RS*GAMS/GAM*GAMM/GAMMS*(1.-PRCPTS** (GAMMS*
1/GAMS))) * PTSPTP * PRCPTS ** (1./GAMS))
AIOAPS = AIOAPS + (1./PRCPTT) ** (1./GAM) / SQRT(1.-PRCPTT ** (GAMM/GAM
1))
AIOAPS = AIOAPS / SQRT(2./GAMM * (GAMP/2.) ** (GAMP/GAMM))
AIOAT = AIOAPS / ATOAPS
PPFCSP = .1 * 10. ** (.0332 * THE TA + .72) * (10. * (AEOAT - 1.)) ** (-.77)
C*** MACH SECTION
ME = 1.
KT = 0
150  FUNKX = AEOAT - 1./ME * ((2. + GAMM * ME ** 2) / GAMP) ** (GAMP / (2. * GAMM))
SVQMEE = ME
CALL ITRATE(ME, FUNKX, 0., KT)
IF (ABS(FUNKX) .LE. 1.E-4) GO TO 160
IF (KT .GT. 25) GO TO 475
IF (KT .EQ. 1) ME = 1.01
IF (SVQMEE - ME .GT. 0.) ME = AMAX1(ME, .5 * (1. + SVQMEE))
IF (SVQMEE - ME .LT. 0.) ME = AMIN1(ME, 1.2 * SVQMEE)
GO TO 150
160  CONTINUE
PTTPE = (1. + GAMM / 2. * ME ** 2) ** (GAM / GAMM)
PTTCP = PPFCSP * PTTPE
IF (PTTCP .GE. ANPR) GO TO 180
CALL AREAS(1./PRCPTT, PTSPTP, GAM, WSOWP1)
AEPAPS = APOAT * AIOAPS
AESAPS = ASOAT * AIOAPS
MEP = MP
MES = MS
X4EXIT = APOAT * MEP + ASOAT * MES
FFS = PRCPTT * AEPAPS * (1. + GAM * MEP ** 2)
FFSS = PRCPTS * PTSPTP * AESAPS * (1. + GAMS * MES ** 2)
PDA = 1./ANPR * ((6. + PRCPTT * ANPR) / 7.) * (AEOAT * ATOAPS - AIOAPS)
FFID = GAM * SQRT(2./GAMM * (2./GAMP) ** (GAMP/GAMM) * (1. - (1./ANPR) ** (GAM
1/GAM)))
FFIDS = WSOWP1 * SQRT(2.*GAM*GAMS/GAMMS*RS/RP*(2./GAMP)** (GAMP/GAMM)
1 * (1. - (1./ANPR * 1./PTSPTP) ** (GAMMS/GAMS)))
CALL XTRP(AIOAT, CS, THETA, FIG11)
IF (MODEL .GE. 2.) CS = CS - .007
TID = FFID + FFIDS
CT = (CS * (FFS + FFSS) - AEOAT * ATOAPS / ANPR + PDA) / (FFID + FFIDS)
FLAG = 3.
X4OM = (PRCPTT * AEPAPS * GAM * MEP ** 2 + PRCPTS * PTSPTP * AESAPS * GAMS * MES **
12) * ANPR * ATFLOW
GO TO 500
180  CALL AREAS(1./PEOPTP, PTSPTP, GAM, WSOWP1)
AEPAPS = APOAT * AEOAT * ATOAPS
AESAPS = ASOAT * AEOAT * ATOAPS
MEP = MP
MES = MS
X4EXAA = APOAT * MEP + ASOAT * MES
FFID = GAM * SQRT(2./GAMM * (2./GAMP) ** (GAMP/GAMM) * (1. - PEOPTP ** (GAMMS
1/GAMS)))

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***CONTINUING

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FFIDS = WSOHP1*SQRT(2.*GAM*GAMS/GAMMS*RS/RP*(2./GAMP)**(GAMP/GAMM))EJECT 283
1 * (1.-PEOPTS**((GAMMS/GAMS)))EJECT 284
FFS = PEOPTP*AEPAPS*(1.+GAM*MEP**2)EJECT 285
FFSS = PEOPTS*PTSPTP*AESAPS*(1.+GAMS*MES**2)EJECT 286
TID1= FFID + FFIDS EJECT 287
CS = .995 EJECT 288
IF(QMODEL .GE.2.)CS=CS-.007 EJECT 289
CTGEO = (CS *(FFS+FFSS)-AEOAT*ATOAPS*PEOPTP)/(FFID+FFIDS) EJECT 290
X4J41= (PEOPTP*AEPAPS*GAM*MEP**2+ PEOPTS*PTSPTP*AESAPS*GAMS*MES**2)EJECT 291
1)*ANPR*ATFLOW EJECT 292
PRCPTT = PRCOPC/PTTPCP EJECT 293
PRCPTS = PRCPTT/PTSPTP EJECT 294
AIOAPS = WSOHP1/(SQRT(RP/RS*GAMS/GAM*GAMM/GAMMS*(1.-PRCPTS**((GAMMS/GAMMS)
1 /GAMS))) *PTSPTP*PRCPTS**((1./GAMS)))EJECT 295
AIOAPS = AIOAPS+(1./PRCPTT)**((1./GAM)/SQRT(1.-PRCPTT**((GAMM/GAM)))EJECT 297
AIOAPS = AIOAPS/SQRT(2./GAMM*(GAMP/2.))**((GAMP/GAMM) ) EJECT 298
AIOAT = AIOAPS/ATOAPS EJECT 299
CALL AREAS(1./PRCPTT,PTSPTP,GAM,WSOWP1) EJECT 300
AEPAPS = APOAT*AIOAPS EJECT 301
AESAPS = ASOAT*AIOAPS EJECT 302
MEP = MP EJECT 303
MES = MS EJECT 304
X4EXBB = APOAT*MEP + ASOAT*MES EJECT 305
FFS = PRCPTT*AEPAPS*(1.+GAM*MEP**2)EJECT 306
FFSS = PRCPTS*PTSPTP*AESAPS*(1.+GAMS*MES**2)EJECT 307
PDA = 1./PTTPCP*((6.+PRCPTT*PTTPCP)/7.)*(AEOAT*ATOAPS-AIOAPS) EJECT 308
FFID = GAM*SQRT(2./GAMM*(2./GAMP)**(GAMP/GAMM))*(1.-(1./PTTPCP)EJECT 309
1 **((GAMM/GAM)))EJECT 310
FFIDS = WSOHP1*SQRT(2.*GAM*GAMS/GAMMS*RS/RP*(2./GAMP)**(GAMP/GAMM))EJECT 311
1 *(1.-(1./PTTPCP*1./PTSPTP)**((GAMMS/GAMS)))EJECT 312
CALL XTRP(AIOAT, CS, THETA, FIG11) EJECT 313
IF (QMODEL .GE.2.)CS = CS-.007 EJECT 314
CTCUSP = (CS*(FFS+FFSS)-AEOAT*ATOAPS/PTTPCP+PDA)/(FFID+FFIDS) EJECT 315
TID2 = FFID + FFIDS EJECT 316
TID = TID2 - (PTTPCP - ANPR)*(TID2-TID1)/(PTTPCP-1./PEOPTP) EJECT 317
CT = CTCUSP-(PTTPCP-ANPR)*(CTCUSP-CTGEO)/(PTTPCP-1./PEOPTP) EJECT 318
X4EXIT=X4EXBB-(PTTPCP-ANPR)*(X4EXBB-X4EXAA)/(PTTPCP-1./PEOPTP) EJECT 319
FLAG = 2. EJECT 320
X4J42= (PRCPTT*AEPAPS*GAM*MEP**2 + PRCPTS*PTSPTP*AESAPS*GAMS*MES**2)EJECT 321
12)*ANPR*ATFLOW EJECT 322
X4QM = X4QM2 - (PTTPCP-ANPR)*(X4QM2-X4QM1)/(PTTPCP-1./PEOPTP) EJECT 323
G) TO 500 EJECT 324
190 CALL AREAS(1./PEUPTP,PTSPTP,GAM,WSOWP1) EJECT 325
AEPAPS = APOAT*AEOAT*ATOAPS EJECT 326
AESAPS = ASOAT*AEOAT*ATOAPS EJECT 327
MEP = MP EJECT 328
MES = MS EJECT 329
X4EXIT = APOAT*MEP + ASOAT*MES EJECT 330
FFID = GAM*SQRT(2./GAMM*(2./GAMP)**(GAMP/GAMM))*(1.-(1./ANPR)**(GAMM/GAMM))EJECT 331
1M/GAM)))EJECT 332
FFIDS = WSOHP1*SQRT(2.*GAM*GAMS/GAMMS*RS/RP*(2./GAMP)**(GAMP/GAMM))EJECT 333
1 *(1.-(1./ANPR*1./PTSPTP)**((GAMMS/GAMS)))EJECT 334
FFS = PEUPTP*AEPAPS*(1.+GAM*MEP**2)EJECT 335
FFSS = PEUPTS*PTSPTP*AESAPS*(1.+GAMS*MES**2)EJECT 336
CALL XTRP(AEOAT, CS, THETA, FIG11) EJECT 337
IF (QMODEL .GE.2.)CS = CS-.007 EJECT 338
TID = FFID + FFIDS EJECT 339

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***CONTINUING


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CT = (CS*(FFS+FFSS)-AEOAT*ATOAPS/ANPR)/(FFID+FFIDS)      EJECT 340
FLAG = 4.                                                    EJECT 341
IF(PEUPTP .GT. 1./ANPR) CTID = (1.*(FFS+FFSS) - AEOAT*ATCAPS/ANPR) EJECT 342
1/(FFID+FFIDS)                                              EJECT 343
X434 = (PEUPTP*AEPAPS*GAM*MEP**2 + PEUPTS*PTSPTP*AESAPS*GAMS*MES** EJECT 344
121*AVPR*ATFLOW                                           EJECT 345
GO TO 500                                                  EJECT 346
C*** BERNST SECTION                                       EJECT 347
200 KT = 0                                                EJECT 348
IF (XX.EQ.0.) POPTPX=POPTPX/2.                             EJECT 349
110 PJPTS=POPTPX/PTSPTP                                    EJECT 350
SVPJPT = PJPTPX                                           EJECT 351
WSWPT = AEJA*SQRT(2./GAMM*(GAMP/2.)*(GAMP/GAMM))-(1./POPTPX)**(1. EJECT 352
1/GAM)/SQRT(1.-POPTPX**((GAMM/GAM))                      EJECT 353
WSWPT = WSWPT*SQRT(RP/RS*GAMS/GAM*GAMM/GAMMS*(1.-POPTS**((GAMMS/ EJECT 354
1/GAMS))) * PTSPTP * PJPTS**((1./GAMS))                  EJECT 355
FUNKK = WSWP - WSWPT                                       EJECT 356
CALL ITRATE(POPTPX,FUNKK, 0., KT)                          EJECT 357
IF (ABS(FUNKK) .LT. 1.E-4) GO TO 240                      EJECT 358
IF (KT .GT. 25) GO TO 470                                 EJECT 359
IF (SVPJPT - POPTPX .GT. 0.) POPTPX=AMAX1(POPTPX, .8*SVPJPT) EJECT 360
IF (SVPJPT - POPTPX .LT. 0.) POPTPX=AMIN1(POPTPX, .5*(SVPJPT+PTSPT EJECT 361
IP))                                                       EJECT 362
IF(KT .EQ. 1) POPTPX = 1.01*POPTPX                       EJECT 363
GO TO 210                                                  EJECT 364
240 PJPTPZ = PJPTPX                                       EJECT 365
IF (BERN - 2 ) 47, 50, 92                                EJECT 366
470 WRITE(6,1060)                                         EJECT 367
GO TO 490                                                  EJECT 368
475 WRITE(6,1050)                                         EJECT 369
GO TO 490                                                  EJECT 370
480 WRITE(6,1040)                                         EJECT 371
GO TO 490                                                  EJECT 372
485 WRITE(6,1030)                                         EJECT 373
490 NOZERR = 1                                             EJECT 374
WRITE(6,9000)                                              EJECT 375
500 CONTINUE                                              EJECT 376
1010 FFORMAT(1H0,*RECOMP PRESS .GT. THROAT PRESS*)      EJECT 377
1020 FFORMAT(*0 SECONDARY FLOW TOTAL PRESSURE LESS THAN FREESTREAM STAT EJECT 378
1C* )                                                     EJECT 379
1030 FFORMAT(*0 PUMPING CHARACTERISTICS ITERATION FAILED* ) EJECT 380
1040 FFORMAT(*0 UNCHOKED WSWP GREATER THAN CHOKED WSWP*) EJECT 381
1050 FFORMAT(*0 MACH NUMBER ITERATION FAILED*)           EJECT 382
1060 FFORMAT(*0 EXIT PRESSURE ITERATION FAILED *)        EJECT 383
9000 FFORMAT(1H ,*ERROR IN EJECTOR NOZZLE ROUTINE*)      EJECT 384
RETJRN                                                    EJECT 385
END                                                        EJECT 386

```

***END

***BEGIN

SUBROUTINE FLTSPD (IFSC, FSPD, AM, VOK, VOM, VOKI, VOMI,
1 PAM, TAM)

INPUT CODES

IFS = 1 MACH NUMBER
IFS = 2 TRUE AIRSPEED, KNOTS
IFS = 3 TRUE AIRSPEED, MPH
IFS = 4 EQUIVALENT AIRSPEED, KNOTS
IFS = 5 EQUIVALENT AIRSPEED, MPH
IFS = 6 CALIBRATED AIRSPEED, KNOTS
IFS = 7 CALIBRATED AIRSPEED, MPH

NOMENCLATURE

AM - MACH NUMBER
VOM - TRUE AIRSPEED (MPH)
VOK - TRUE AIRSPEED (KTS)
VOMI - EQUIVALENT AIRSPEED (MPH)
VOKI - EQUIVALENT AIRSPEED (KTS)
COMMON/FLTSP/ VCASKT, VCASMP
COMMON/GCALCC/ALTO, ALTX, ALTER, GEOPH
DIMENSION GAM (72)

DATA GAM /2.0,1.0,0.0,68.,

10100.0,1.402,0150.0,1.402,0200.0,1.402,0250.0,1.402,0300.0,1.402,
20350.0,1.402,0400.0,1.402,0450.0,1.401,0500.0,1.401,0550.0,1.400,
30600.0,1.399,0650.0,1.398,0700.0,1.396,0750.0,1.394,0800.0,1.392,
40900.0,1.387,1000.0,1.381,1100.0,1.374,1200.0,1.368,1300.0,1.362,
51400.0,1.356,1500.0,1.350,1600.0,1.345,1700.0,1.340,1800.0,1.336,
61900.0,1.332,2000.0,1.328,2100.0,1.325,2200.0,1.322,2300.0,1.319,
72400.0,1.317,2600.0,1.313,2800.0,1.309,3000.0,1.306/

DIMENSION VQCAS1(155), VQCAS2(60), VEQCAS(215)

EQUIVALENCE (VEQCAS(1),VQCAS1), (VEQCAS(156),VQCAS2)

DIMENSION VCASV1(155), VCASV2(60), VCASEQ(215)

EQUIVALENCE (VCASEQ(1),VCASV1), (VCASEQ(156),VCASV2)

DATA VCASV1 / 4.0 , 1.0 , 0.0 , 30.0 , 7.0

A , 8.0 , 0.0 , 0.0 , 0.0 , 250. , 250. , 500. , 500. ,

B , 750. , 750. , 20*0.0

C , 28.0 , 5000. , 0.0 , 0.0 , 100. , 100. , 150. , 149.8

D , 200. , 199.6 , 250. , 249.2 , 300. , 298.5 , 350. , 347.8

E , 400. , 396.8 , 450. , 445.6 , 500. , 494.2 , 550. , 542.4

F , 600. , 590. , 650. , 638. , 700. , 685.0

G , 26. , 15000. , 0.0 , 0.0 , 100. , 99.8 , 150. , 149.2

H , 200. , 198.2 , 250. , 246.6 , 300. , 294.5 , 350. , 341.8

I , 400. , 388.4 , 450. , 434. , 500. , 479.1 , 550. , 524. ,

J , 600. , 567. , 650. , 611. , 2*0.0

K , 22.0 , 25000. , 0.0 , 0.0 , 100. , 99.4 , 150. , 148.2

L , 200. , 196.2 , 250. , 243.1 , 300. , 288.9 , 350. , 333.1

M , 400. , 376.1 , 450. , 418.1 , 500. , 460. , 550. , 498. ,

N , 6*0.0

O , 18.0 , 35000. , 0.0 , 0.0 , 100. , 99. , 150. , 147. ,

P , 200. , 193.4 , 250. , 237.9 , 300. , 280.3 , 350. , 321.4

Q , 400. , 362. , 450. , 402. , 10*0.0

DATA VCASV2 /

FLTSP000
FLTSP001
FLTSP002
FLTSP003
FLTSP004
FLTSP005
FLTSP006
FLTSP007
FLTSP008
FLTSP009
FLTSP010
FLTSP011
FLTSP012
FLTSP013
FLTSP014
FLTSP015
FLTSP016
FLTSP017
FLTSP018
FLTSP019
FLTSP020
FLTSP021
FLTSP022
FLTSP023
FLTSP024
FLTSP025
FLTSP026
FLTSP027
FLTSP028
FLTSP029
FLTSP030
FLTSP031
FLTSP032
FLTSP033
FLTSP034
FLTSP035
FLTSP036
FLTSP037
FLTSP038
FLTSP039
FLTSP040
FLTSP041
FLTSP042
FLTSP043
FLTSP044
FLTSP045
FLTSP046
FLTSP047
FLTSP048
FLTSP049
FLTSP050
FLTSP051
FLTSP052
FLTSP053

***CONTINUING

A	16.0	, 450C0.,	0.0	, 0.0	,100.	, 98.4	, 150.	, 145.	FLTSP054
B	200.	, 188.8	, 250.	, 229.8	, 300.	, 269.1	, 350.	, 304.	FLTSP055
C	400.	, 340.	, 12*0.0						FLTSP056
D	12.0	, 550C0.,	0.0	, 0.0	,100.	, 97.4	, 150.	, 141.7	FLTSP057
E	200.	, 182.6	, 250.	, 220.5	, 300.	, 257.	, 16*0.0		/FLTSP058
	DATA VQCAS1	/	4.0	, 1.0	, 0.0	, 30.0	, 7.0		FLTSP059
A	8.0	, 0.0	, 0.0	, 0.0	, 250.	, 250.	, 500.	, 500.	FLTSP060
B	750.	, 750.	, 20*0.0						FLTSP061
C	28.0	, 500C.,	0.0	, 0.0	, 100.	, 100.	, 149.8	, 150.	FLTSP062
D	199.6	, 200.	, 249.2	, 250.	, 298.6	, 300.	, 347.8	, 350.	FLTSP063
E	396.8	, 400.	, 445.6	, 450.	, 494.2	, 500.	, 542.4	, 550.	FLTSP064
F	590.	, 600.	, 638.	, 650.	, 685.	, 700.			FLTSP065
G	26.	, 150C0.,	0.0	, 0.0	, 99.8	, 100.	, 149.2	, 150.	FLTSP066
H	198.2	, 200.	, 246.6	, 250.	, 294.6	, 300.	, 341.8	, 350.	FLTSP067
I	388.4	, 400.	, 434.	, 450.	, 479.1	, 500.	, 524.	, 550.	FLTSP068
J	567.	, 600.	, 611.	, 650.	, 2*0.0				FLTSP069
K	22.0	, 250C0.,	0.0	, 0.0	, 99.4	, 100.	, 148.2	, 150.	FLTSP070
L	196.2	, 200.	, 243.1	, 250.	, 288.8	, 300.	, 333.1	, 350.	FLTSP071
M	376.1	, 400.	, 418.1	, 450.	, 460.	, 500.	, 498.	, 550.	FLTSP072
N	6*0.0								FLTSP073
O	18.	, 350C0.,	0.0	, 0.0	, 99.	, 100.	, 147.	, 150.	FLTSP074
P	193.4	, 200.	, 237.9	, 250.	, 280.3	, 300.	, 321.4	, 350.	FLTSP075
Q	362.	, 400.	, 402.	, 450.	, 10*0.0				/FLTSP076
	DATA VQCAS2	/							FLTSP077
A	16.0	, 450C0.,	0.0	, 0.0	, 98.4	, 100.	, 145.	, 150.	FLTSP078
B	188.8	, 200.	, 229.8	, 250.	, 269.1	, 300.	, 304.	, 350.	FLTSP079
C	340.	, 400.	, 12*0.0						FLTSP080
D	12.0	, 550C0.,	0.0	, 0.0	, 97.4	, 100.	, 141.7	, 150.	FLTSP081
E	182.6	, 200.	, 220.5	, 250.	, 257.	, 300.	, 16*0.0	/	FLTSP082
	IF(ALTER.GT.0.C.AND.ALTER.LT.55000.0) GO TO 9								FLTSP083
	ALTER=0.0								FLTSP084
9	CALL XTRP(TAM, GAMO, 0.0, GAM)								FLTSP085
	SQTAM = SQRT(TAM)								FLTSP086
	SQGAM = SQRT(GAMO)								FLTSP087
	AD = 41.427 * SQRT(TAM) * SQRT(GAMO)								FLTSP088
	SQSIG = SQRT(PAM / (TAM * 4.0793))								FLTSP089
	GJ TJ (10, 20, 30, 40, 50, 60, 70) , IFSC								FLTSP090
10	AM = FSPD								FLTSP091
	VJK = AM * AD * .5925								FLTSP092
11	IF(IFSC .EQ. 4) GO TO 13								FLTSP093
	VJKI = VOK * SQSIG								FLTSP094
	IF(IFSC .EQ. 3) GO TO 14								FLTSP095
13	VJM = VOK / 0.869								FLTSP096
	IF(IFSC .EQ. 5) GO TO 15								FLTSP097
14	VJMI = VOKI / 0.869								FLTSP098
	IF(IFSC .EQ. 6 .OR. IFSC .EQ. 7) GO TO 80								FLTSP099
15	CALL XTRP(VOKI, VCASKT, ALTER, VEQCAS)								FLTSP100
	VCASMP = VCASKT / 0.869								FLTSP101
	GJ TJ 80								FLTSP102
20	VJK = FSPD								FLTSP103
21	AM = VOK * 1.6878 / AD								FLTSP104
	GJ TJ 11								FLTSP105
30	VJM = FSPD								FLTSP106
	VJK = VOM * 0.869								FLTSP107
	GJ TJ 21								FLTSP108
40	VJKI = FSPD								FLTSP109
	VJK = VOKI / SQSIG								FLTSP110

***CONTINUING

```

      GJ TJ 21
50    VDMI = FSPD
      VJK = VDMI *.869/SQSIG
      GJ TJ 21
60    VCASKT = FSPD
      CALL XTRP(VCASKT, VOKI, ALTER, VCASEQ)
      VJK = VOKI / SQSIG
      VCASMP = VCASKT / 0.869
      GJ TJ 21
70    VCASMP = FSPD
      VCASKT = FSPD * 0.869
      CALL XTRP(VCASKT, VOKI, ALTER, VCASEQ)
      VJK = VOKI / SQSIG
      GJ TJ 21
80    RETURN
      END

***END

```

```

FLTSP111
FLTSP112
FLTSP113
FLTSP114
FLTSP115
FLTSP116
FLTSP117
FLTSP118
FLTSP119
FLTSP120
FLTSP121
FLTSP122
FLTSP123
FLTSP124
FLTSP125
FLTSP126

```

***BEGIN

SUBROUTINE ITERAT(G,V,X,N)	ITERA000
X= 1.1	ITERA001
Q= 1.0001	ITERA002
W1=SQRT(G)*ATAN(SQRT(1.0/G*(Q**2-1.0)))-ATAN(SQRT(Q**2-1.0))	ITERA003
I= 0	ITERA004
10 I=I+1	ITERA005
IF(I. LE. 200) GO TO 20	ITERA006
WRITE(6,9900)	ITERA007
N=2	ITERA008
RETURN	ITERA009
20 W= SQRT(G)*ATAN(SQRT(1.0/G*(X**2-1.0)))-ATAN(SQRT(X**2-1.0))	ITERA010
IF(ABS(V-W).LT. 0.0001)RETURN	ITERA011
X1= Q+(V-W1)/(W-W1)*(X-Q)	ITERA012
Q=X	ITERA013
X= X1	ITERA014
W1=W	ITERA015
GO TO 10	ITERA016
9900 FORMAT(* FAILED TO CONVERGE IN ITERAT*)	ITERA017
END	ITERA018

***END

***BEGIN

```
      SUBROUTINE ITRATE(A3P,B3,B3P,LOOP)
      IF (LOOP) 100,102,100
100    A31=A3
      B31=B32
102    A3=A3P
      B32=B3-B3P
      IF (LOOP) 104,106,104
104    DIVISOR=B32-B31
      IF (DIVISOR.EQ.C.) GO TO 106
      A3P=(B32*A31-B31*A3)/DIVISOR
106    LOOP=LOOP+1
      RETURN
      END
```

ITRTE000
ITRTE001
ITRTE002
ITRTE003
ITRTE004
ITRTE005
ITRTE006
ITRTE007
ITRTE008
ITRTE009
ITRTE010
ITRTE011
ITRTE012

***END

***BEGIN

SUBROUTINE ITRATI(X,G,XMIN,XMAX,NUMIT,NSIGX,NSIGF,KONV)	ITRTI000
F = G	ITRTI001
IF(KONV.NE. 0) GO TO 20	ITRTI002
C ... INITIAL ENTRY	ITRTI003
XAVE = (XMAX + XMIN) / 2.E0	ITRTI004
IF((XMAX - X) * (X - XMIN) .GE. 0.E0) GO TO 10	ITRTI005
X = XAVE	ITRTI006
GO TO 70	ITRTI007
10 KONV = 1	ITRTI008
LJOP = 0	ITRTI009
FLEAST = 1.E60	ITRTI010
XS = X	ITRTI011
FS = F	ITRTI012
LIMITS = 0	ITRTI013
NUMIT2 = NUMIT/2	ITRTI014
XMIN = XMIN	ITRTI015
XMAX = XMAX	ITRTI016
20 DABSF = ABS(F)	ITRTI017
IF(DABSF .GT. ABS(FLEAST)) GO TO 22	ITRTI018
C ... SAVE BEST VALUE	ITRTI019
SAVX = X	ITRTI020
FLEAST = F	ITRTI021
C ... TRY TO DECREASE INTERVAL OF APPROXIMATION	ITRTI022
22 IF(LIMITS .EQ. 1) GO TO 25	ITRTI023
IF(F*FS .GT. 0.E0) GO TO 28	ITRTI024
LIMITS = 1	ITRTI025
IF(X .GT. XS) GO TO 23	ITRTI026
XMIN = X	ITRTI027
XMAX = XS	ITRTI028
FMIN = F	ITRTI029
FMAX = FS	ITRTI030
GO TO 28	ITRTI031
23 XMIN = XS	ITRTI032
XMAX = X	ITRTI033
FMIN = FS	ITRTI034
FMAX = F	ITRTI035
GO TO 28	ITRTI036
25 IF(F*FMNN .LT. 0.E0) GO TO 26	ITRTI037
XMIN = X	ITRTI038
FMIN = F	ITRTI039
FMAX = FMXX/2.E0	ITRTI040
GO TO 28	ITRTI041
26 XMAX = X	ITRTI042
FMAX = F	ITRTI043
FMIN = FMNN/2.E0	ITRTI044
C ... TEST FOR CONVERGENCE	ITRTI045
28 C = ABS(XMIN)	ITRTI046
IF(C .EQ. 0.E0) C = 1.E0	ITRTI047
IF((ABS(XMAX - XMIN) / C .LT. 5.E-1*1.E1**(-NSIGX) .AND. DABSF	ITRTI048
1 .LT. 5.E-1*1.E1**(-NSIGF)) .OR. DABSF .EQ. 0.E0) GO TO 80	ITRTI049
IF(LJOP .GT. 0) GO TO 30	ITRTI050
C ... PERTURB INITIAL GUESS	ITRTI051
X = X+ SIGN(1.E-2*X, XAVE-X)	ITRTI052
IF(X .EQ. XS) X = (XAVE+XMIN)/2.E0	ITRTI053

***CONTINUING

GO TO 60	ITRTI054
C ... TEST FOR NONCONVERGENCE	ITRTI055
30 IF(LOOP .EQ. NUMIT) GO TO 90	ITRTI056
C ... REGLA FALSI	ITRTI057
IF(LIMITS .NE. 1 .OR. LOOP .LE. NUMIT2) GO TO 50	ITRTI058
X = (FMNN*XMXX - FMXX*XMNN)/(FMNN - FMXX)	ITRTI059
IF(ABS(FMNN) .GT. 1.E1 .AND. ABS(FMXX) .GT. 1.E1 .AND.	ITRTI060
1 ABS(FMNN-FMXX)/AMIN1(ABS(FMNN), ABS(FMXX)) .GT. 1.E2)	ITRTI061
2 X = (XMXX+XMNN) / 2.E0	ITRTI062
GO TO 65	ITRTI063
50 DIV = F-FS	ITRTI064
IF(DIV .EQ. 0.E0) DIV = 1.E0	ITRTI065
X1 = (F*XS-FS*X)/DIV	ITRTI066
XS = X	ITRTI067
FS = F	ITRTI068
X = X1	ITRTI069
C ... TEST FOR OUT OF RANGE	ITRTI070
60 IF(X .LE. XMNN) X = (XS+XMNN)/2.E0	ITRTI071
IF(X .GE. XMXX) X = (XS+XMXX)/2.E0	ITRTI072
C ... INCREASE ITERATION COUNTER	ITRTI073
65 LOOP = LOOP+1	ITRTI074
C ... RETURN	ITRTI075
70 RETURN	ITRTI076
C ... CONVERGENCE	ITRTI077
80 KCONV = 2	ITRTI078
GO TO 70	ITRTI079
C ... NONCONVERGENCE	ITRTI080
90 KCONV = 3	ITRTI081
IF(LIMITS .EQ. 1) GO TO 70	ITRTI082
X = SAVX	ITRTI083
G = FLEAST	ITRTI084
GO TO 70	ITRTI085
END	ITRTI086
***END	

***BEGIN

SUBROUTINE ITRATA(N,X,F,XMIN,XMAX,EPS,NUMIT,KONV)	ITRTA000
DIMENSION A(15,15),B(15,15),C(15,15),D(14),S(14),P(14),	ITRTA001
1 X(N),F(N),DS(14),XS(14),FS(14),TS(15),XMIN(N),XMAX(N),	ITRTA002
2 EPS(N),G(15,15),E(15,15),Q(15,15),R(15,15),	ITRTA003
3 DF(14)	ITRTA004
FUNC(A1,B1,C1,M) = AMIN1((B1-A1),(A1-C1))/M	ITRTA005
IF (KONV .GE. 1) GO TO 25	ITRTA006
C . INITIALIZATION	ITRTA007
KPT = 1	ITRTA008
LJCAL = 0	ITRTA009
KUT = 2	ITRTA010
DNN = -1.E60	ITRTA011
DO 6 J=1,N	ITRTA012
DNN = AMAX1(DNN, ABS(ALOG10(EPS(J)))+1.F-2)	ITRTA013
DF(J) = 1.E1	ITRTA014
6 D(J) = 0.E0	ITRTA015
NN = N+DNN+5	ITRTA016
NNN = NUMIT/NN+1	ITRTA017
KONV = 1	ITRTA018
ST = 1.E70	ITRTA019
N1= N+1	ITRTA020
7 JJJ=0	ITRTA021
L = 0	ITRTA022
8 DO 10 J=1,N1	ITRTA023
10 A(J,1) = 1.E0	ITRTA024
KOMPUT = 0	ITRTA025
K=0	ITRTA026
PMIN = 1.E70	ITRTA027
DO 15 J=1,N	ITRTA028
DS(J) = D(J)	ITRTA029
D(J) = X(J)	ITRTA030
S(J) = FUNC(X(J),XMAX(J),XMIN(J),KPT*(NN-N))	ITRTA031
P(J) = AMIN1(.1E0* ABS(X(J))+1.E-4, S(J)/(10*KPT))*	ITRTA032
1 SIGN(1.E0, D(J)-DS(J))	ITRTA033
IF(ABS(P(J)) .GT. PMIN) GO TO 15	ITRTA034
PMIN = ABS(P(J))	ITRTA035
15 CONTINUE	ITRTA036
DETMIN = 1.F-9*AMIN1(1.E0,PMIN**N)	ITRTA037
C . CONVERGENCE TEST	ITRTA038
25 DO 35 J=1,N	ITRTA039
IF(ABS(F(J)) .GT. EPS(J)) GO TO 40	ITRTA040
35 CONTINUE	ITRTA041
C . CONVERGENCE	ITRTA042
KONV=2	ITRTA043
GO TO 440	ITRTA044
C . COMPUTE CONVERGENCE FUNCTION	ITRTA045
40 T=0.E0	ITRTA046
DO 42 J=1,N	ITRTA047
42 T=T+ ABS(F(J))	ITRTA048
C . SAVE BEST VALUE	ITRTA049
IF(T .GE. ST) GO TO 46	ITRTA050
IF(L .GT. 0) L=L-1	ITRTA051
IF(LJCAL .EQ. C) L=0	ITRTA052
ST = T	ITRTA053

***CONTINUING

DO 44 J=1,N	ITRTA054
XS(J) = X(J)	ITRTA055
FS(J) = F(J)	ITRTA056
IF(LOCAL .EQ. 1) GO TO 44	ITRTA057
S(J) = FUNC(X(J),XMAX(J),XMIN(J),NN-JJJ)	ITRTA058
44 CONTINUE	ITRTA059
C . TEST FOR DISCONTINUITY	ITRTA060
46 IF(KUT .EQ. 4) GO TO 49	ITRTA061
DO 48 J=1,N	ITRTA062
IF(X(J) .EQ. XS(J)) GO TO 48	ITRTA063
DFJ = 0.E0	ITRTA064
DO 47 I = 1, N	ITRTA065
47 DFJ = AMAX1(DFJ, ABS((F(I)-FS(I))/(X(J)-XS(J))))	ITRTA066
IF(KMPUT .EQ. 0) DF(J) = AMAX1(DFJ, DF(J))	ITRTA067
IF(DFJ .LE. 1.E2*DF(J)) GO TO 48	ITRTA068
LOCAL = 1	ITRTA069
KUT = 4	ITRTA070
GO TO 49	ITRTA071
48 CONTINUE	ITRTA072
C . JJJ COUNTS THE NUMBER OF ITERATIONS	ITRTA073
49 JJJ = JJJ+1	ITRTA074
IF (JJJ-NN) 50,94,94	ITRTA075
C . REPLACE WORST POINT	ITRTA076
50 IF(KMPUT .EQ. 0) GO TO 100	ITRTA077
TT = 0.E0	ITRTA078
DO 65 J=1,N1	ITRTA079
IF(TS(J)-TT) 65,65,60	ITRTA080
60 TT = TS(J)	ITRTA081
MAXROW = J	ITRTA082
65 CONTINUE	ITRTA083
A(MAXROW,1) = 1.E0	ITRTA084
DO 85 J=1,N	ITRTA085
A(MAXROW,J+1) = F(J)/EPS(J)	ITRTA086
85 B(MAXROW,J) = X(J)	ITRTA087
TS(MAXROW) = T	ITRTA088
GO TO 135	ITRTA089
C . STORE BEST VALUE	ITRTA090
94 DO 95 JT=1,N	ITRTA091
F(JT) = FS(JT)	ITRTA092
95 X(JT) = XS(JT)	ITRTA093
KPT = KPT+1	ITRTA094
IF(KPT .GT. NNN/2) LOCAL=1	ITRTA095
IF(KPT .GT. NNN) GO TO 98	ITRTA096
GO TO 7	ITRTA097
C . NONCONVERGENCE	ITRTA098
98 KJNV = 3	ITRTA099
GO TO 440	ITRTA100
C . BUILD MATRIX OF POINTS	ITRTA101
100 K=K+1	ITRTA102
DO 115 J=1,N	ITRTA103
A(K,J+1) = F(J)/EPS(J)	ITRTA104
115 B(K,J) = X(J)	ITRTA105
TS(K) = T	ITRTA106
IF (K-N) 120,120,130	ITRTA107
120 X(K) = X(K)+P(K)	ITRTA108
IF(K-1) 440,440,125	ITRTA109
125 X(K-1) = D(K-1)	ITRTA110

GO TO 440	ITRTA111
C . SOLVE LINEAR SYSTEM	ITRTA112
130 X (K-1) = D(K-1)	ITRTA113
KJMPUT = 1	ITRTA114
135 DO 140 I = 1,N1	ITRTA115
G(I,N1) = A(I,N1)	ITRTA116
Q(I,N1) = 1.E0	ITRTA117
DO 140 J = 1,N	ITRTA118
Q(I,J) = B(I,J)	ITRTA119
140 G(I,J) = A(I,J)	ITRTA120
DO 210 I1=1,N1	ITRTA121
DO 200 J1=1,N1	ITRTA122
R(I1,J1) = 0.EC	ITRTA123
200 E(I1,J1) = 0.EC	ITRTA124
DO 210 K1=1,N	ITRTA125
210 C(I1,K1) = 0.EC	ITRTA126
DO 230 J2=2,N1	ITRTA127
DO 230 I2=1,N1	ITRTA128
R(J2,J2-1) = R(J2,J2-1) + Q(I2,J2)**2	ITRTA129
230 E(J2,J2-1) = E(J2,J2-1) + 3(I2,J2)**2	ITRTA130
DO 340 K3=1,N1	ITRTA131
DO 300 J3=K3,N1	ITRTA132
DO 250 I3=1,N1	ITRTA133
R(K3,J3) = R(K3,J3) + Q(I3,K3)*Q(I3,J3)	ITRTA134
250 E(K3,J3) = E(K3,J3) + G(I3,K3)*G(I3,J3)	ITRTA135
IF (K3 - J3) 2E0,260,260	ITRTA136
260 IF (K3 - 1) 3C0,300,270	ITRTA137
270 IF (1.E-14*(E(K3,K3-1)-1.E14*E(K3,K3))) 275,340,340	ITRTA138
275 IF (1.E-14*(R(K3,K3-1)-1.E14*R(K3,K3))) 300, 340, 340	ITRTA139
280 IF (E(K3,K3) .LT. 1.E-60) GO TO 340	ITRTA140
IF (R(K3,K3) .LT. 1.E-60) GO TO 340	ITRTA141
E(K3,J3) = E(K3,J3)/E(K3,K3)	ITRTA142
R(K3,J3) = R(K3,J3)/R(K3,K3)	ITRTA143
DO 290 I4=1,N1	ITRTA144
Q(I4,J3) = Q(I4,J3) - Q(I4,K3)*R(K3,J3)	ITRTA145
290 G(I4,J3) = G(I4,J3) - G(I4,K3)*E(K3,J3)	ITRTA146
300 CONTINUE	ITRTA147
DO 340 J5=1,N	ITRTA148
DO 310 I5=1,N1	ITRTA149
310 C(K3,J5) = C(K3,J5) + G(I5,K3)*B(I5,J5)/E(K3,K3)	ITRTA150
340 CONTINUE	ITRTA151
DO 350 I7=2,N1	ITRTA152
IT = N1+1-I7	ITRTA153
JT = IT + 1	ITRTA154
DO 350 J7=1,N	ITRTA155
DO 350 K7=JT,N1	ITRTA156
350 C(IT,J7) = C(IT,J7) - E(IT,K7)*C(K7,J7)	ITRTA157
C . DETERMINE IF MATRIX IS SINGULAR	ITRTA158
DET = 1.E0	ITRTA159
DET1 = 1.E0	ITRTA160
DO 360 JMT=1,N1	ITRTA161
DET = DET* ABS(E(JMT,JMT))	ITRTA162
360 DET1 = DET1* ABS(R(JMT,JMT))	ITRTA163
IF (DET1 .GT. DETMIN**2 .AND. DET .GT. 1.E-20) GO TO 380	ITRTA164
DO 370 J=1,N	ITRTA165
X(J) = XS(J)	ITRTA166
370 F(J) = FS(J)	ITRTA167

***CONTINUING

GO TO 8	ITRTA168
C . TEST PREDICTIONS FROM MATRIX SOLUTION TO KEEP WITHIN BOUNDS	ITRTA169
380 L = L+1	ITRTA170
DO 430 J=1,N	ITRTA171
X(J) = C(1,J)	ITRTA172
IF(LJCAL .EQ. C) GO TO 420	ITRTA173
STEP = S(J)/KUT**(L-1)	ITRTA174
IF(ABS(X(J)-XS(J)) .GT. STEP) X(J) = XS(J)+ SIGN(STEP,X(J)-XS(J))	ITRTA175
GO TO 430	ITRTA176
420 IF(X(J) .LE. XMIN(J)) X(J)=XS(J)-L*S(J)	ITRTA177
IF(X(J) .GE. XMAX(J)) X(J)=XS(J)+L*S(J)	ITRTA178
430 CONTINUE	ITRTA179
440 RETURN	ITRTA180
END	ITRTA181
***END	

***BEGIN

SUBROUTINE LSTDAT(NTAPE)	LSTDAT01
DIMENSION CARD(20)	LSTDAT02
INTEGER CARD,END1	LSTDAT03
DATA END1/*END */	LSTDAT04
DATA	LSTDAT05
NEWP/*NEWP*/	LSTDAT06
J=NTAPE	LSTDAT07
REWIND J	LSTDAT08
5 LINE =0	LSTDAT09
WRITE (6,101)	LSTDAT10
101 FORMAT (11H1INPUT DATA/14H CARD COLUMNS ,	LSTDAT11
1 40H123456789C123456789012345678901234557890,	LSTDAT12
2 40H123456789C123456789012345678901234557890/1HJ)	LSTDAT13
10 READ (5,106) CARD	LSTDAT14
IF (CARD(1).EQ.END1) GO TO 20	LSTDAT15
IF (CARD(1).EQ.NEWP) GO TO 5	LSTDAT16
WRITE (J,106) CARD	LSTDAT17
WRITE (6,103) CARD	LSTDAT18
LINE=LINE+1	LSTDAT19
IF (LINE-55) 1C,5,5	LSTDAT20
102 FORMAT (1H1)	LSTDAT21
106 FORMAT (20A4)	LSTDAT22
103 FORMAT (14X,2CA4)	LSTDAT23
20 WRITE(J,106)CARD	LSTDAT24
WRITE(6,103)CARD	LSTDAT25
WRITE (6,104)	LSTDAT26
REWIND J	LSTDAT27
104 FORMAT (9H0END DATA)	LSTDAT28
RETURN	LSTDAT29
END	

***END

***BEGIN

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SUBROUTINE NOZPLG(AT,AEAT,XE,THETAD,APB,GAMMA,PTNPP,CDN,CT,FLAG,
1 NOZERR ,TID,CS,QMODEL,MO,CTID,XMUM,ATMIN,ATMAX,XMEXIT)
REAL    MO,KIDCL3,KIDCS3,KICVL3,KICVS3
DIMENSION KICVL3(71) , KICVS3(93)
DIMENSION KIDCL3(71) , KIDCS3(93)
DATA KIDCL3 / 5., 1., 0., 22., 3.,
A      20., 0., 0., -.017, .002, -.021, .004, -.022,
B      .006, -.023, .01, -.02, .014, -.016, .018, -.014,
C      .02, -.015, .024, -.019, .028, -.025,
D      20., .6, 0., -.017, .002, -.021, .004, -.022,
E      .006, -.023, .01, -.02, .014, -.016, .018, -.014,
F      .02, -.015, .024, -.019, .028, -.025,
G      20., .9, 0., -.0295, .01, -.0295, .014, -.029,
H      .02, -.0285, .024, -.029, .028, -.03, .032, -.033,
I      .036, -.036, .038, -.039, .04, -.042 /
DATA KIDCS3 / 5., 1., 0., 22., 4.,
A      20., 0., 0., -.034, .002, -.03, .004, -.026,
B      .006, -.023, .008, -.021, .012, -.019, .016, -.018,
C      .02, -.018, .024, -.019, .03, -.022,
D      20., .6, 0., -.034, .002, -.03, .004, -.026,
E      .006, -.023, .008, -.021, .012, -.019, .016, -.018,
F      .02, -.018, .024, -.019, .03, -.022,
G      20., .8, 0., -.075, .002, -.064, .004, -.056,
H      .006, -.0495, .008, -.0445, .012, -.037, .016, -.031,
I      .02, -.027, .024, -.025, .03, -.023,
J      20., .9, 0., -.104, .002, -.08, .004, -.064,
K      .006, -.055, .008, -.05, .012, -.046, .016, -.043,
L      .02, -.041, .024, -.039, .03, -.037 /
DATA KICVL3 / 5., 1., 0., 22., 3.,
A      20., 0., 0., 0., .004, -.0002, .008, -.0005,
B      .012, -.0008, .016, -.001, .02, -.0013, .022, -.0015,
C      .024, -.0016, .026, -.0018, .028, -.0019,
D      20., .6, 0., 0., .004, -.0002, .008, -.0005,
F      .012, -.0008, .016, -.001, .02, -.0013, .022, -.0015,
F      .024, -.0016, .026, -.0018, .028, -.0019,
G      20., .9, 0., 0., .004, .0003, .006, .0002,
H      .008, -.0007, .012, -.0023, .016, -.0035, .02, -.0044,
I      .026, -.0053, .032, -.006, .04, -.0065 /
DATA KICVS3 / 5., 1., 0., 22., 4.,
A      20., 0., 0., 0., .002, -.0001, .004, -.0002,
B      .006, -.0004, .008, -.0006, .012, -.0011, .016, -.0016,
C      .02, -.0021, .024, -.0026, .028, -.0030,
D      20., .6, 0., 0., .002, -.0001, .004, -.0002,
E      .006, -.0004, .008, -.0006, .012, -.0011, .016, -.0016,
F      .02, -.0021, .024, -.0026, .028, -.0030,
G      20., .8, 0., 0., .002, .0004, .004, .0006,
H      .006, .0007, .008, .0003, .012, -.0008, .016, -.0019,
I      .02, -.003, .024, -.0041, .028, -.0052,
J      20., .9, 0., 0., .002, .0008, .004, .0015,
K      .006, .0019, .008, .0011, .012, -.0005, .016, -.0019,
L      .02, -.0032, .024, -.0045, .028, -.0057 /
NOZERR= 0
FLAG= 4.0
CTID = 1.

```

NOZPL 000
 NOZPL 001
 NOZPL 002
 NOZPL 003
 NOZPL 004
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 NOZPL 053

***CONTINUING

GAMBO = (GAMMA+1.0)/(GAMMA-1.0)	NOZPL 054
GAMBA = 1.0/GAMBO	NOZPL 055
GAM1 = GAMMA-1.0	NOZPL 056
GAP1 = GAMMA+1.0	NOZPL 057
PRCRIT = (GAP1/2.0)**(GAMMA/GAM1)	NOZPL 058
IF (PTNPP .GT. PRCRIT) GO TO 10	NOZPL 059
NOZERR = 1	NOZPL 060
WRITE(6,9915)	NOZPL 061
GO TO 90	NOZPL 062
10 THETAP = THETAD*0.0174533	NOZPL 063
RCOS1 = COS(THETAP)	NOZPL 064
RCOS2 = COS(THETAP)**2	NOZPL 065
RE = SQRT(APB/3.141592)	NOZPL 066
R1 = RE + TAN(THETAP)*XE	NOZPL 067
AE = AEAT*AT	NOZPL 068
RS = (R1*RCOS1*((1.0-RCOS2)+SQRT(R1**2*RCOS2+AE/3.141592	NOZPL 069
1 *RCOS1*(2.0-RCOS2)))/(RCOS1*(2.0-RCOS2))	NOZPL 070
RT = RS-RCOS2*(RS-R1)	NOZPL 071
XT = (R1-RT)/SIN(THETAP)	NOZPL 072
S = (RS-RT)/RCOS1	NOZPL 073
CS = RCOS1	NOZPL 074
IF (MODEL .GE. 2.0) CS = CS-.007	NOZPL 075
THETAR = -THETAP	NOZPL 076
AME = 1.0001	NOZPL 077
AEASK = 1.0	NOZPL 078
IF (AEAT .EQ. 1.0) GO TO 50	NOZPL 079
ABE = 0.9	NOZPL 080
AME = 1.0	NOZPL 081
ICOUNT = 0	NOZPL 082
AEAP = AEAT/CDN	NOZPL 083
20 ICOUNT = ICOUNT+1	NOZPL 084
IF (ICOUNT .LE. 200) GO TO 30	NOZPL 085
WRITE(6,9900)	NOZPL 086
NOZERR = 1	NOZPL 087
RETURN	NOZPL 088
30 AEASK = 1.0/AME*((2.0/GAP1*(1.0+GAM1/2.0*AME**2))**((GAP1/(2.0*GAM1)))	NOZPL 089
IF (ABS(AEAP-AEASK) .LT. 0.001) GO TO 50	NOZPL 090
IF (AEAP-AEASK) 35,35,40	NOZPL 091
35 AME = ABE+(AEAP-ASSE)/(AEASK-ASSE)*(AME-ABE)	NOZPL 092
GO TO 20	NOZPL 093
40 ASSE = AEASK	NOZPL 094
ABE = AME	NOZPL 095
AME = AME+0.1	NOZPL 096
GO TO 20	NOZPL 097
50 PEPTN = (1.0+GAM1/2.0*AME**2)**((-GAMMA/GAM1)	NOZPL 098
FSAA = PEPTN*AEASK*(1.0+GAMMA*AME**2)	NOZPL 099
PTPINV = 1.0/PTNPP	NOZPL 100
XMOD = PEPTN*AEASK*GAMMA*AME**2*PTPINV*AT*CDN	NOZPL 101
XEXIT = AME	NOZPL 102
FIPTA = GAMMA*SQRT(2.0/GAM1*(2.0/GAP1)**GAMBO*(1.0-PTPINV **	NOZPL 103
1 (GAM1/GAMMA)))	NOZPL 104
TID = FIPTA	NOZPL 105
CTE = (CS*FSAA-PTPINV*AEASK)/FIPTA	NOZPL 106
IF (AEASK .EQ. 1.0) CTE = CTE + PTPINV*(1.0/CDN-1.0)/FIPTA	NOZPL 107
IF (NO .LT. 1.0) GO TO 95	NOZPL 108
A = R1	NOZPL 109
B = -TAN(THETAP)	NOZPL 110

***CONTINJING

VE=SQRT(GAMBO)*ATAN(SQRT(1.0/GAMBO*(AME**2-1.0)))-ATAN(SQRT(NOZPL 111
1 AME**2-1.0))	NOZPL 112
AMEXP= SQRT(2.0/GAM1*(PTNPP**2*(GAM1/GAMMA)-1.0))	NOZPL 113
AMVEXP= SQRT(GAMBO)*ATAN(SQRT(GAMBO*(AMEXP**2-1.0)))-ATAN(SQRT(NOZPL 114
1 AMEXP**2-1.0))	NOZPL 115
AJEXP= ATAN(1.0/SQRT(AMEXP**2-1.0))	NOZPL 116
THEXP= THETAR+AMVEXP-VE-AJEXP	NOZPL 117
THMAX= ATAN((RE-RS)/XE)	NOZPL 118
IF(THEXP.LE. THMAX) GO TO 60	NOZPL 119
THEXP= THMAX	NOZPL 120
RMAX= SQRT(GAMBO*TAN(SQRT(1.0/GAMBO)*(THEXP-THETAR+VE+1.570796))**	NOZPL 121
12 +1.0)	NOZPL 122
AMVEXP= SQRT(GAMBO)*ATAN(SQRT(1.0/GAMBO*(RMAX**2-1.0)))-	NOZPL 123
1 ATAN(SQRT(RMAX**2-1.0))	NOZPL 124
60 BB= TAN(THEXP)	NOZPL 125
AA= RS	NOZPL 126
XI=-(A-AA)/(B-BB)	NOZPL 127
RI= A+B*XI	NOZPL 128
PIPTN= PEPTN	NOZPL 129
RS1= RT	NOZPL 130
NUM=(AMVEXP-VE)/.0174533	NOZPL 131
IF(NUM.LT. 5) NUM=5	NOZPL 132
RUM= NUM	NOZPL 133
CTD= 0.0	NOZPL 134
PSPTN= 0.0	NOZPL 135
DO 80 J=1,NUM	NOZPL 136
Q= J	NOZPL 137
VL= VE+ Q/RUM *(AMVEXP-VE)	NOZPL 138
CALL ITERAT(GAMBO,VL,AML,NOZERR)	NOZPL 139
IF(NOZERR.EQ.0)GO TO 65	NOZPL 140
WRITE(6,9905)	NOZPL 141
GO TO 90	NOZPL 142
65 AUL= ATAN(1.0/SQRT(AML**2-1.0))	NOZPL 143
THETL= THETAR+VL-VE-AUL	NOZPL 144
BB= TAN(THETL)	NOZPL 145
AA= RS	NOZPL 146
XL=-(A-AA)/(B-BB)	NOZPL 147
RL= A+B*XL	NOZPL 148
VC= 2.0*VL	NOZPL 149
CALL ITERAT(GAMBO,VC,XMC,NOZERR)	NOZPL 150
IF(NOZERR.EQ.0)GO TO 70	NOZPL 151
WRITE(6,9905)	NOZPL 152
GO TO 90	NOZPL 153
70 PCPTN= (1.0+GAM1/2.0*XMC**2) **(-GAMMA/GAM1)	NOZPL 154
CTD= CTD+1.0/FIPTA*(0.5*(PIPTN+PCPTN)-PTPINV)*(RS1**2-RL**2)	NOZPL 155
1 *3.141592/(CDN*AT)	NOZPL 156
RS1= RL	NOZPL 157
PIPTN= PCPTN	NOZPL 158
IF(XL.EQ. XE) PSPTN= PCPTN	NOZPL 159
80 CJNTINUE	NOZPL 160
PBPTN= 4.312/PTNPP**1.975	NOZPL 161
PB1PTN= 0.517*PSPTN+ 0.0046	NOZPL 162
PB2PTN=PTPINV	NOZPL 163
IF(PBPTN.GT. PB2PTN) PBPTN= PB2PTN	NOZPL 164
IF(PB1PTN.GT. PBPTN) PBPTN= PB1PTN	NOZPL 165
CTBD= (PBPTN-PTPINV)*APB/(CDN*AT*FIPTA)	NOZPL 166
IF(PEPTN.GT. PTPINV) CTID= (FSAA-PTPINV*AEASK)/FIPTA+CTD+CTBD	NOZPL 167

	CT = CTE + CTD + CTBD	NOZPL 168
90	RETURN	NOZPL 169
95	CALL XTRP(1.-CTID,DELDL,MO,KICVL3)	NOZPL 170
	CALL XTRP(1.-CTID,DELDS,MO,KICVS3)	NOZPL 171
	CALL XTRP(1.-CTID,DELCL,MO,KIDCL3)	NOZPL 172
	CALL XTRP(1.-CTID,DELCS,MO,KIDCS3)	NOZPL 173
	DELD = DELDS + (AT-ATMIN)*(DELDL-DELDS)/(ATMAX-ATMIN)	NOZPL 174
	DELC = DELCS + (AT-ATMIN)*(DELCL-DELCS)/(ATMAX-ATMIN)	NOZPL 175
	CT = DELD + DELC + CTID	NOZPL 176
	GJ TO 90	NOZPL 177
9900	FORMAT(* NOZZLE EXIT MACH NUMBER ITERATION FAILED*)	NOZPL 178
9905	FORMAT(* NOZPLG--MACH ITERATION FAILED AT LOCAL EXPANSION ANGLE*)	NOZPL 179
9915	FORMAT(* NOZPLG--PLUG NOZZLE MUST BE CHOKED*)	NOZPL 180
	END	NOZPL 181

***END

***BEGIN

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SUBROUTINE NOZZLE(AT,ATFLOW,AEAT,GAMMA,PTTPFS,QMODEL,NT,FL,CDN,CT,NOZZL000
1 FLAG,NOZERR ,TID,CS,XMOM,CTID,A,XMEXIT) NOZZL001
DIMENSION FIGB1A(157), FIGB1B(40) , FIGB1(197) NOZZL002
DIMENSION FIG11A(157) , FIG11B(112) , FIG11(269) NOZZL003
EQUIVALENCE (FIG11A(1),FIG11(1)), (FIG11B(1),FIG11(158)), NOZZL004
1 (FIGB1A(1),FIGB1(1)), (FIGB1B(1),FIGB1(158)) NOZZL005
DATA FIG11A / 5., 1., 0., 24., 11., NOZZL006
A 14., 0., 1.025, .997, 1.1, .997, 1.2, .997, NOZZL007
B 1.3, .997, 1.4, .997, 1.5, .997, 1.56, .997, NOZZL008
C 0., 0., 0., 0., 0., 0., 0., 0., NOZZL009
D 14., 2., 1.025, .997, 1.1, .997, 1.2, .997, NOZZL010
E 1.2, .997, 1.25, .996, 1.3, .995, 1.3, .995, NOZZL011
F 0., 0., 0., 0., 0., 0., 0., 0., NOZZL012
G 20., 4., 1.025, .997, 1.1, .997, 1.2, .997, NOZZL013
H 1.3, .997, 1.33, .997, 1.33, .997, 1.4, .9965, NOZZL014
I 1.5, .996, 1.6, .9952, 1.63, .995, 0., 0., NOZZL015
J 22., 6., 1.025, .997, 1.1, .997, 1.2, .997, NOZZL016
K 1.4, .997, 1.5, .997, 1.56, .997, 1.56, .997, NOZZL017
L 1.6, .996, 1.7, .9945, 1.8, .993, 2.0, .9928, NOZZL018
M 22., 8., 1.025, .997, 1.06, .997, 1.06, .997, NOZZL019
N 1.1, .9955, 1.2, .9945, 1.3, .995, 1.4, .9955, NOZZL020
O 1.5, .996, 1.6, .9965, 1.8, .996, 2.0, .994, NOZZL021
P 22., 10., 1.025, .997, 1.045, .997, 1.045, .997, NOZZL022
Q 1.1, .993, 1.2, .991, 1.3, .991, 1.4, .9915, NOZZL023
R 1.5, .992, 1.6, .9925, 1.8, .9935, 2.0, .994, NOZZL024
S 22., 12., 1.025, .997, 1.032, .997, 1.032, .997/ NOZZL025
DATA FIG11B / NOZZL026
A 1.1, .9915, 1.2, .9875, 1.3, .986, 1.4, .9862, NOZZL027
B 1.5, .9865, 1.6, .9875, 1.8, .989, 2.0, .990, NOZZL028
C 22., 14., 1.025, .997, 1.032, .997, 1.032, .997, NOZZL029
D 1.1, .990, 1.2, .9835, 1.3, .9815, 1.4, .981, NOZZL030
E 1.5, .981, 1.6, .9812, 1.8, .982, 2.0, .9835, NOZZL031
F 22., 16., 1.025, .997, 1.025, .997, 1.1, .988, NOZZL032
G 1.2, .9815, 1.3, .978, 1.4, .976, 1.5, .975, NOZZL033
H 1.6, .9753, 1.7, .9756, 1.8, .976, 2.0, .977, NOZZL034
I 22., 18., 1.025, .997, 1.1, .986, 1.2, .978, NOZZL035
J 1.3, .973, 1.4, .971, 1.5, .969, 1.6, .968, NOZZL036
K 1.7, .968, 1.8, .968, 1.9, .9685, 2.0, .969, NOZZL037
L 22., 20., 1.025, .997, 1.1, .9845, 1.2, .976, NOZZL038
M 1.3, .970, 1.4, .966, 1.5, .963, 1.6, .9622, NOZZL039
N 1.7, .9618, 1.8, .9615, 1.9, .9612, 2.0, .9612 / NOZZL040
DATA FIGB1A / 4., 1., 0., 24., 8., NOZZL041
A 22., 0., 1.0, 0., 1.05, .001, 1.1, .002, NOZZL042
B 1.2, .004, 1.3, .008, 1.4, .011, 1.6, .019, NOZZL043
C 1.8, .026, 2.2, .04, 3.0, .062, 3.8, .076, NOZZL044
D 22., 3., 1.0, 0., 1.05, .001, 1.1, .002, NOZZL045
E 1.2, .004, 1.3, .008, 1.4, .011, 1.6, .019, NOZZL046
F 1.8, .026, 2.2, .04, 3.0, .062, 3.8, .076, NOZZL047
G 22., 5., 1.0, 0., 1.05, .002, 1.1, .004, NOZZL048
H 1.2, .007, 1.3, .011, 1.4, .015, 1.6, .026, NOZZL049
I 1.8, .037, 2.2, .057, 3.0, .09, 3.8, .11, NOZZL050
J 22., 7.5, 1.0, 0., 1.05, .0025, 1.1, .005, NOZZL051
K 1.2, .01, 1.3, .016, 1.4, .024, 1.6, .041, NOZZL052
L 1.8, .057, 2.2, .086, 3.0, .136, 3.8, .164, NOZZL053

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***CONTINUING

M	22.,	10.,	1.0,	0.,	1.05,	.004,	1.1,	.0075,	NOZZL 054
N	1.2,	.012,	1.3,	.022,	1.4,	.032,	1.6,	.053,	NOZZL 055
O	1.8,	.074,	2.2,	.113,	3.0,	.18,	3.8,	.216,	NOZZL 056
P	22.,	15.,	1.0,	0.,	1.05,	.006,	1.1,	.012,	NOZZL 057
Q	1.2,	.025,	1.3,	.04,	1.4,	.058,	1.6,	.094,	NOZZL 058
R	1.8,	.130,	2.2,	.202,	3.0,	.315,	3.8,	.38,	NOZZL 059
S	22.,	20.,	1.0,	0.,	1.05,	.008,	1.1,	.014,	NOZZL 060
DATA FIG1B /									NOZZL 061
A	1.2,	.028,	1.3,	.048,	1.4,	.07,	1.6,	.124,	NOZZL 062
B	1.8,	.18,	2.2,	.268,	3.0,	.375,	3.25,	.40,	NOZZL 063
C	22.,	90.,	1.0,	0.,	1.05,	.009,	1.1,	.017,	NOZZL 064
D	1.2,	.034,	1.3,	.057,	1.4,	.082,	1.5,	.111,	NOZZL 065
E	1.6,	.14,	1.8,	.195,	2.2,	.302,	2.77,	.40 /	NOZZL 066
RAD = .0174533									NOZZL 067
G12GM1 = (GAMMA+1)/(2.*(GAMMA-1.))									NOZZL 068
PI = 3.1415927									NOZZL 069
GRAV = 32.174									NOZZL 070
RRR = 1716.5									NOZZL 071
FLG220 = 0.									NOZZL 072
NOZERR = 0									NOZZL 073
LJOP = 0									NOZZL 074
CTID = 1.0									NOZZL 075
5	QMT = 1.								NOZZL 076
ATFLAT = CDN									NOZZL 077
PTPFS = PTPFS									NOZZL 078
PFSPTT = 1./PTPFS									NOZZL 079
FLAGAT=0.									NOZZL 080
IF(PTPFS .LT. ((GAMMA+1.)/2.))*((GAMMA/(GAMMA-1.))) FLAGAT=1.									NOZZL 081
FLAGMT=0.									NOZZL 082
DMT=.1									NOZZL 083
FPTATS = GAMMA*SQRT((2./(GAMMA-1.))*(2./(GAMMA+1.))*((2.*G12GM1))									NOZZL 084
1*(1.-PFSPTT*((GAMMA-1.)/GAMMA)))									NOZZL 085
AE = AEAT*AT									NOZZL 086
IF(NT .EQ. 1) GO TO 75									NOZZL 087
RT = SQRT(AT/PI)									NOZZL 088
RE = SQRT(AE/PI)									NOZZL 089
THET = ATAN((RE-RT)/SQRT(FL-(RE-RT)**2))									NOZZL 090
THETA = THET/RAD									NOZZL 091
GO TO 80									NOZZL 092
42	FSAATS = PEPTT*AEATS*(1.+GAMMA*QME**2)								NOZZL 093
CALL XTRP(AEATS, CS, THETA, FIG11)									NOZZL 094
IF(QMODEL .EQ. 2.)CS = CS-.007									NOZZL 095
XMEEXIT = QME									NOZZL 096
XMOD = PEPTT*AEATS*GAMMA*QME**2*PTPFS*ATFLOW									NOZZL 097
IF (PEPTT .GT. PFSPTT) CTID = (FSAATS-PFSPTT*AEATS)/FPTATS									NOZZL 098
TID = FPTATS									NOZZL 099
CT = (CS*FSAATS- PFSPTT*AEATS)/FPTATS									NOZZL 100
FLAG=4.									NOZZL 101
GO TO 500									NOZZL 102
75	IF(FLAGAT .EQ. 1) GO TO 162								NOZZL 103
C***	CONVERGENT NOZZLE -- CHOKED								NOZZL 104
CS = .997									NOZZL 105
IF(QMODEL .EQ. 2.)CS = CS-.007									NOZZL 106
ATFATS = 1.									NOZZL 107
AEATS = 1./ATFLAT									NOZZL 108
PEPTT = ((GAMMA+1.)/2.))*((-GAMMA/(GAMMA-1.))									NOZZL 109
PMAX = ((GAMMA+1.)/2.))*((GAMMA/(GAMMA-1.))									NOZZL 110

***CONTINUING

	PEPFS = PEPTT*PTPFS	NOZZL 111
	FSAAS = ATFATS*PEPTT*(1.+GAMMA)	NOZZL 112
	PVARB = PEPTT	NOZZL 113
	FLAG=4.	NOZZL 114
	IF (PTPFS .GE. A) GO TO 77	NOZZL 115
	FLAG = 5.	NOZZL 116
	PVARB = PFSPTT + (PEPTT-PFSPTT)*(PTPFS-PMAX)/(A-PMAX)	NOZZL 117
77	XMOD = GAMMA*PTPFS*PVARB*AE	NOZZL 118
	TID = FPTATS	NOZZL 119
	XEXIT = 1.	NOZZL 120
	CT = (CS*(FSAAS+PVARB*(AEATS-ATFATS) - PFSPTT*AEATS))/FPTATS	NOZZL 121
	IF(PTPFS .GT. PVARB)CTID = (FSAAS + PVARB*(AEATS-ATFATS) - PFSPTT	NOZZL 122
	1 * AEATS)/FPTATS	NOZZL 123
	GJ TO 500	NOZZL 124
80	CALL XTRP(AEAT , DPTQT, THETA, FIGB1)	NOZZL 125
	QMT = 1.	NOZZL 126
90	IF(LLOOP .GT. 5)GO TO 480	NOZZL 127
	LLOOP = LLOOP + 1	NOZZL 128
	PTTQT = 2.*(1+.5*(GAMMA-1.)*QMT**2)**(GAMMA/(GAMMA-1.))/(GAMMA*	NOZZL 129
	1 QMT**2)	NOZZL 130
	PTEQT = PTTQT - DPTQT	NOZZL 131
	PTEPTT = PTEQT/PTTQT	NOZZL 132
	QMCALC = GRAV*SQRT(GAMMA/RRR)*QMT*(1+.5*(GAMMA-1.)*QMT**2)**(-G12	NOZZL 133
	1GM1)	NOZZL 134
	QEXIT = SORT(2.*(PFSPTT**((1.-GAMMA)/GAMMA)-1.)/(GAMMA-1.))	NOZZL 135
	IF(FLAGAT.EQ.0.)QEXIT=1.	NOZZL 136
	QCID = GRAV*SQRT(GAMMA/RRR)*QEXIT*(1+.5*(GAMMA-1.)*QEXIT**2)**(-	NOZZL 137
	1-G12GM1)	NOZZL 138
	CON = QMCALC/QCID*ATFLAT	NOZZL 139
	ATSAT =	NOZZL 140
	1 ATFLAT*QMT*((2.+(GAMMA-1.)*QMT**2)/(GAMMA+1.))**(-G12GM1)	NOZZL 141
	AESAT = ATSAT/PTEPTT	NOZZL 142
	AESAE = AESAT/AEAT	NOZZL 143
	AEAES = 1./AESAE	NOZZL 144
	IF (AEAES .LT. 1.) GO TO 485	NOZZL 145
110	QMEE = .5	NOZZL 146
	KT = 0	NOZZL 147
120	FUNC2 = AEAES- ((2.+(GAMMA-1.)*QMEE**2)/(GAMMA+1.))**G12GM1/QMEE	NOZZL 148
	SVQMEE = QMEE	NOZZL 149
	CALL ITRATE(QMEE, FUNC2, 0., KT)	NOZZL 150
	IF (ABS(FUNC2) .LE. 1.E-4) GO TO 140	NOZZL 151
	IF (KT .GT. 25) GO TO 475	NOZZL 152
	IF (KT .EQ. 1) QMEE = .51	NOZZL 153
	IF (SVQMEE - QMEE .GT. 0.)QMEE = AMAX1(QMEE, .8*SVQMEE)	NOZZL 154
	IF (SVQMEE - QMEE .LT. 0.)QMEE = AMIN1(QMEE, .5*(SVQMEE+1.))	NOZZL 155
	GJ TO 120	NOZZL 156
140	PEPTE = (1+.5*(GAMMA-1.)*QMEE**2)**(-GAMMA/(GAMMA-1.))	NOZZL 157
	PEPTT = PEPTE * PTEPTT	NOZZL 158
	PTTPE = 1./PEPTT	NOZZL 159
	IF (ABS(PTPFS -PTTPE) .LE. 5.E-3) GO TO 161	NOZZL 160
	IF (PTPFS .GE. PTTPE) GO TO 150	NOZZL 161
	IF(FLAGMT.NE.1.) GO TO 145	NOZZL 162
	DMT=DMT/2.	NOZZL 163
	FLAGMT=0.	NOZZL 164
145	QMT = QMT-DMT	NOZZL 165
	GJ TO 90	NOZZL 166
150	IF (QMT .GE. 1.) GO TO 163	NOZZL 167

***CONTINUING

	IF(FLAGMT.NE.0.) GO TO 155	NOZZL 168
	DMT=DMT/2.	NOZZL 169
	FLAGMT=1.	NOZZL 170
155	QMT = QMT+DMT	NOZZL 171
	GO TO 90	NOZZL 172
161	CS = .995	NOZZL 173
	IF(QMODEL.EQ.2.)CS = CS-.007	NOZZL 174
	AEATS = AEAT/ATSAT	NOZZL 175
	QMX = SQRT(2./((GAMMA-1.)*((1./PEPTE)*((GAMMA-1.)/GAMMA)-1.))	NOZZL 176
	FSAAS = PEPIT*AEATS*(1.+GAMMA*QMX**2)	NOZZL 177
	XMQM = PEPIT*AEATS*GAMMA*QMX**2*PTT*PFS*ATFLOW	NOZZL 178
	TID = FPTATS	NOZZL 179
	XEXIT = QMX	NOZZL 180
	CT = (CS*FSAAS - PEPIT*AEATS)/FPTATS	NOZZL 181
	FLAG=1.	NOZZL 182
	GO TO 500	NOZZL 183
162	CS = .997	NOZZL 184
	IF(QMODEL.EQ.2.)CS = CS-.007	NOZZL 185
	QMT = SQRT(2.*(PFSPTT*((1.-GAMMA)/GAMMA) -1.)/(GAMMA-1.))	NOZZL 186
	ATFATS = ((2. + (GAMMA-1.)*QMT**2)/(GAMMA+1.))*G12GM1/QMT	NOZZL 187
	PEPFS = 1.	NOZZL 188
	FSAAS = ATFATS*PFSPTT*(1.+GAMMA*QMT**2)	NOZZL 189
	AEATS = ATFATS/ATFLAT	NOZZL 190
	TID = FPTATS	NOZZL 191
	PTPE = ((GAMMA+1.)/2.)*((GAMMA/(GAMMA-1.))	NOZZL 192
	XMQM = GAMMA*PTPFS/PTPE*AE*QMT**2	NOZZL 193
	XEXIT = QMT	NOZZL 194
	CT = (CS*(FSAAS + PFSPTT*(AEATS-ATFATS)) - PFSPTT*AEATS)/FPTATS	NOZZL 195
	FLAG=1.	NOZZL 196
	GO TO 500	NOZZL 197
163	AFATS=AEAT/ATSAT	NOZZL 198
	QME = 1.	NOZZL 199
	KT = 0	NOZZL 200
165	FUNC1 = AFATS - ((2.+(GAMMA-1.)*QME**2)/(GAMMA+1.))*G12GM1/QME	NOZZL 201
	SVQME = QME	NOZZL 202
	CALL ITRATE(QME, FUNC1, 0., KT)	NOZZL 203
	IF (ABS(FUNC1) .LE. 1.E-4) GO TO 170	NOZZL 204
	IF (KT .GT. 25) GO TO 475	NOZZL 205
	IF (KT .EQ. 1) QME = 1.01	NOZZL 206
	IF (SVQME - QME .GT. 0.) QME = AMAX1(QME, .5*(1.+SVQME))	NOZZL 207
	IF (SVQME - QME .LT. 0.) QME = AMIN1(QME, 1.2*SVQME)	NOZZL 208
	GO TO 165	NOZZL 209
170	PEPTT = (1. + .5* QME**2 *((GAMMA-1.))*((-GAMMA/(GAMMA-1.))	NOZZL 210
175	WSWP = 0.	NOZZL 211
	PREPFS = .63 +.04*ALOG(WSWP+.01)	NOZZL 212
	PREPTT = PREPFS/PTT*PFS	NOZZL 213
	IF(FLG220.EQ.1.) PREPTT=PECUPT*PREPFS	NOZZL 214
	IF(PREPTT.LE.0.)GO TO 42	NOZZL 215
	QMX = SQRT(2./((GAMMA-1.)*((PREPTT)*((1.-GAMMA)/GAMMA)-1.))	NOZZL 216
	QMT=QMX	NOZZL 217
	AREATS = ((2.+QMX**2*(GAMMA-1.))/(GAMMA+1.))*G12GM1/QMX	NOZZL 218
200	CALL XTRPI(AREATS,CS, THETA, FIG11)	NOZZL 219
	IF(QMODEL.EQ.2.)CS = CS-.007	NOZZL 220
	PECUSP = .1*(1.C**(.0332*THETA+.72)) * (10.*(AEAT-1.))*(-.77)	NOZZL 221
	PIPTT = PREPTT	NOZZL 222
	PETPTT = PEPTT	NOZZL 223
	P2PTT = PEPTT/PREPFS	NOZZL 224

***CONTINUING

	PECUPT = PEPTT/PECUSP	NOZZL 225
	IF(PECUPT.GT. PETPTT) GO TO 219	NOZZL 226
	IF(PECUPT.GT. P2PTT) GO TO 218	NOZZL 227
	PREPTT = PEPTT	NOZZL 228
	AREATS = AEATS	NOZZL 229
	QMI = QME	NOZZL 230
	PECUPT = P2PTT	NOZZL 231
	GJ TJ 220	NOZZL 232
218	IF (PTTPFS .LE. 1./PECUPT) GO TO 220	NOZZL 233
219	FSAAS = PIPTT* (1.+GAMMA*QMI**2)*AREATS	NOZZL 234
	QT = PFSPTT*(6.+PTTPFS*PREPTT)*(AEATS-AREATS)/7.	NOZZL 235
	XMDM = PIPTT*AREATS*GAMMA*QMI**2*PTTPFS*ATFLOW	NOZZL 236
	TID = FPTATS	NOZZL 237
	XMEXIT = QMI	NOZZL 238
	CT = (CS*FSAAS - AEATS /PTTPFS + QT)/FPTATS	NOZZL 239
	FLAG=3.	NOZZL 240
	GJ TJ 500	NOZZL 241
220	PTTQT = 2.*(1.+5*(GAMMA-1.))**((GAMMA/(GAMMA-1.))	NOZZL 242
	PTEQT = PTTQT - OPTQT	NOZZL 243
	PTEPTT = PTEQT/PTTQT	NOZZL 244
	PTEPE = PTEPTT/PETPTT	NOZZL 245
	PTTPET = 1./PETPTT	NOZZL 246
	QMEF = SQRT(2.*(PTTPET **((GAMMA-1.)/GAMMA)-1.)/(GAMMA-1.))	NOZZL 247
	QMEX = SQRT(2.*(PTEPE **((GAMMA-1.)/GAMMA)-1.)/(GAMMA-1.))	NOZZL 248
	AEATS = ((2.+(GAMMA-1.)*QMEF**2)/(GAMMA+1.))**G12GM1/QMEF	NOZZL 249
	FSAAS = AEATS*(1.+GAMMA*QMEX**2)/PTTPET	NOZZL 250
	FPTATS = GAMMA*SQRT((2./(GAMMA-1.))*(2./(GAMMA+1.))**((2.*G12GM1)	NOZZL 251
	1*(1.-PETPTT**((GAMMA-1.)/GAMMA)))	NOZZL 252
	XMDM1 = PETPTT*AEATS*GAMMA*QMEX**2*PTTPFS*ATFLOW	NOZZL 253
	FPTAT1 = FPTATS	NOZZL 254
	CS = .995	NOZZL 255
	IF(QMODEL.EQ. 2.)CS = CS-.007	NOZZL 256
	CTSUBP = (CS *FSAAS -PETPTT*AEATS)/FPTATS	NOZZL 257
	IF(FLG220.EQ.1.)GO TO 225	NOZZL 258
	FLG220 = 1.	NOZZL 259
	GJ TJ 175	NOZZL 260
225	QT = PECUPT*((6.+PREPTT/PECUPT)/7.)*(AEATS-AREATS)	NOZZL 261
	FSAAS2= PREPTT*AREATS*(1.+GAMMA*QMI**2)	NOZZL 262
	FPTATS = GAMMA*SQRT((2./(GAMMA-1.))*(2./(GAMMA+1.))**((2.*G12GM1)	NOZZL 263
	1*(1.-PECUPT**((GAMMA-1.)/GAMMA)))	NOZZL 264
	CALL XTRP(AEATS,CS, THETA, FIG11)	NOZZL 265
	IF(QMODEL.EQ. 2.)CS = CS-.007	NOZZL 266
	XMDM2 = PREPTT*AREATS*GAMMA*QMI**2*PTTPFS*ATFLOW	NOZZL 267
	CTCUSP = (CS*FSAAS2-AEATS *PECUPT + QT)/FPTATS	NOZZL 268
	XMDM = (XMDM2-XMDM1)*(PTPFS-PTEPE)/(1./PECUPT-PTEPE) + XMDM1	NOZZL 269
	TID = (FPTATS - FPTAT1) * (PTPFS-PTEPE)/(1./PECUPT - PTEPE)+FPTAT1	NOZZL 270
	XMEXIT=(QMI-QMEX)*(PTPFS-PTEPE)/(1./PECUPT-PTEPE)+QMI	NOZZL 271
	CT = (CTCUSP-CTSUBP)*(PTPFS-PTEPE)/(1./PECUPT-PTEPE) + CTCUSP	NOZZL 272
	FLAG=2.	NOZZL 273
	GJ TJ 500	NOZZL 274
475	WRITE(6,630)	NOZZL 275
	GJ TJ 490	NOZZL 276
480	WRITE(6,620)	NOZZL 277
	GJ TJ 490	NOZZL 278
485	WRITE(6,610)	NOZZL 279
490	NOZERR = 1	NOZZL 280
	WRITE(6,600)	NOZZL 281

***CONTINUING

```
500 RETURN
600 F3R4T(1H1,*----ERROR IN NOZZLE----*)
610 F3R4T(1H,*COMPUTED NOZZLE DIVERGENCE AREA LESS THAN 1.*)
620 F3R4T(1H,*NOZZLE THROAT AREA ITERATION FAILED*)
630 F3R4T(1H,*NOZZLE EXIT MACH NUMBER ITERATION FAILED*)
    END
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NOZZL 282
NOZZL 283
NOZZL 284
NOZZL 285
NOZZL 286
NOZZL 287
```

***END

***BEGIN

SUBROUTINE XTRP(X,Y,Z,CV)	XTRP 000
C CURVE INTERPOLATION AND EXTRAPOLATION	XTRP 001
C SAME EXCEPT TRAP ADDED TO CALL EXIT WHEN A CURVE IS MISSING	XTRP 002
C QUADRATIC FIT ON BIVARIANT INTERPOLATION	XTRP 003
C MINIMUM STORAGE VERSION, X MUST INCREASE	XTRP 004
DIMENSION CV(10)	XTRP 005
AX=X	XTRP 006
AZ=Z	XTRP 007
CV(3)=0.0	XTRP 008
ICV=CV(1)+0.1	XTRP 009
IF(ICV.EQ.5) ICV=4	XTRP 010
IF(ICV.GT.0 .AND. ICV.LT.5) GO TO 901	XTRP 011
WRITE(6,900) ICV	XTRP 012
900 FORMAT(45H CURVE MISSING OR WRONG IN A CALL TO XTRP, ID ,I4)	XTRP 013
RELLIM=-5.0	XTRP 014
HTLIHP=SQRT(RELLIM)	XTRP 015
FFOEG=CV(1000000)	XTRP 016
CALL EXIT	XTRP 017
901 CONTINUE	XTRP 018
GO TO (1000,2000,3000,4000),ICV	XTRP 019
C UNIVARIATE LINEAR	XTRP 020
1000 N= CV(4)+ 4.0	XTRP 021
IF (AX-CV(5)) 1080,1050,1017	XTRP 022
1017 DO 1025 I=7,N,2	XTRP 023
IF (AX-CV(I)) 1040,1040,1025	XTRP 024
1025 CONTINUE	XTRP 025
GO TO 1060	XTRP 026
C COMPUTE	XTRP 027
1040 LRET=3	XTRP 028
GO TO 3900	XTRP 029
1050 A=CV(6)	XTRP 030
1045 Y=A	XTRP 031
GO TO 9999	XTRP 032
C EXTRAPOLATION	XTRP 033
1060 CV(3)=1.0	XTRP 034
I=N-1	XTRP 035
IF (CV(2)) 1040,9999,1040	XTRP 036
1080 CV(3)=1.0	XTRP 037
I=7	XTRP 038
IF (CV(2)) 1040,9999,1040	XTRP 039
C UNIVARIATE QUADRATIC	XTRP 040
2000 N=CV(4)+4.0	XTRP 041
IF (CV(5)-AX) 2010,1050,2200	XTRP 042
2010 DO 2015 I= 9,N,2	XTRP 043
IF (CV(I)-AX) 2015,2020,2020	XTRP 044
2015 CONTINUE	XTRP 045
GO TO 2225	XTRP 046
2020 IF (CV(I-2)-CV(I-4)) 2025,2250,2025	XTRP 047
2025 LRET=4	XTRP 048
GO TO 5000	XTRP 049
C EXTRAPOLATION	XTRP 050
2200 CV(3)=1.0	XTRP 051
I=9	XTRP 052
IF (CV(2)) 2025,9999,2025	XTRP 053

***CONTINUING

2225	CV(3)=1.0		XTRP 054
	I=N-1		XTRP 055
	IF (CV(2))	2025,9999,2025	XTRP 056
2250	I=I+2		XTRP 057
	GO TO 2025		XTRP 058
C	BIVARIATE LINEAR		XTRP 059
3000	K000FX=CV(4)		XTRP 060
3035	IF (CV(7)-AZ)	3040,3040,3200	XTRP 061
3040	NZ=CV(5)-1.0		XTRP 062
	DO 3045 J=1,NZ		XTRP 063
	LCZ=7+J*K000FX		XTRP 064
	IF (CV(LCZ)-AZ)	3045,3050,3050	XTRP 065
3045	CONTINUE		XTRP 066
	GO TO 3400		XTRP 067
3050	NX=CV(LCZ-1)		XTRP 068
	KX1=LCZ+1		XTRP 069
	JX=KX1+NX-1		XTRP 070
3100	IF (CV(KX1)-AX)	3105,3105,3352	XTRP 071
3105	DO 3110 I=KX1,JX,2		XTRP 072
	IF (CV(I)-AX)	3110,3115,3115	XTRP 073
3110	CONTINUE		XTRP 074
	LRET=1		XTRP 075
	GO TO 3375		XTRP 076
3115	LRET=2		XTRP 077
	GO TO 3900		XTRP 078
3120	Y2=A		XTRP 079
	IF (AZ.NE.CV(LCZ))	GO TO 8801	XTRP 080
	Y = Y2		XTRP 081
	GO TO 9999		XTRP 082
8801	LCZ=LCZ-K000FX		XTRP 083
	KX1=LCZ+1		XTRP 084
	IF (CV(KX1)-AX)	3125,3125,3353	XTRP 085
3125	NX=CV(LCZ-1)		XTRP 086
	JX=KX1+NX-1		XTRP 087
	DO 3130 I=KX1,JX,2		XTRP 088
	IF (CV(I)-AX)	3130,3135,3135	XTRP 089
3130	CONTINUE		XTRP 090
	LRET=2		XTRP 091
	GO TO 3375		XTRP 092
3135	LRET=1		XTRP 093
	GO TO 3900		XTRP 094
3085	Y1=A		XTRP 095
	IF (AZ.NE.CV(LCZ))	GO TO 3950	XTRP 096
	Y = Y1		XTRP 097
	GO TO 9999		XTRP 098
C	EXTRAPOLATION		XTRP 099
3200	CV(3)=1.0		XTRP 100
	LCZ=7+K000FX		XTRP 101
	IF (CV(2))	9999,9999,3050	XTRP 102
3352	LRET=1		XTRP 103
	GO TO 3355		XTRP 104
3353	LRET=2		XTRP 105
3355	CV(3)=1.0		XTRP 106
	IF (CV(2))	3360,9999,3360	XTRP 107
3360	I=KX1+2		XTRP 108
	GO TO (3115,3135),LRET		XTRP 109
3375	CV(3)=1.0		XTRP 110

IF (CV(2))	3380,9999,3380	XTRP 111
3380 I=JX-1		XTRP 112
GO TO (3115,3135),LRET		XTRP 113
3400 CV(3)=1.0		XTRP 114
LCZ=7+NZ*K000FX		XTRP 115
IF (CV(2))	9999,9999,3050	XTRP 116
C CJMPUTE		XTRP 117
3900 A= (AX-CV(I-2))*(CV(I+1)-CV(I-1))/(CV(I)-CV(I-2))+CV(I-1)		XTRP 118
GO TO (30E5,3120,1045),LRET		XTRP 119
3950 LZIN = LCZ+ K000FX		XTRP 120
Y= (AZ-CV(LCZ))*(Y2-Y1)/(CV(LZINI)-CV(LCZ))+Y1		XTRP 121
GO TO 9999		XTRP 122
C BIVARIATE QUADRATIC		XTRP 123
4000 K000FX=CV(4)		XTRP 124
4015 IF (CV(7)-AZ) 4020,4020,4100		XTRP 125
4020 NZ=CV(5)-1.0		XTRP 126
DO 4025 J=2,NZ		XTRP 127
LCZ=7+J*K000FX		XTRP 128
IF (CV(LCZ)-AZ) 4025,4030,4030		XTRP 129
4025 CONTINUE		XTRP 130
GO TO 4200		XTRP 131
4030 LCZM1K = LCZ - 1*K000FX		XTRP 132
LCZM2K = LCZ - 2*K000FX		XTRP 133
IF (CV(LCZM1K) - CV(LCZM2K)) 4040,4035,4040		XTRP 134
4035 LCZ = LCZ + K000FX		XTRP 135
4040 NE = CV(LCZ-1)		XTRP 136
KX1=LCZ+1		XTRP 137
KX3=LCZ+5		XTRP 138
JX=LCZ+NE-1		XTRP 139
Z3=CV(LCZ)		XTRP 140
4300 IF (CV(KX1)-AX) 4310,4310,4450		XTRP 141
4310 DO 4320 I=K>3,JX,2		XTRP 142
IF (CV(I)-AX) 4320,4325,4325		XTRP 143
4320 CONTINUE		XTRP 144
LRET=1		XTRP 145
GO TO 4500		XTRP 146
4325 IF (CV(I-2)-CV(I-4)) 4330,4630,4330		XTRP 147
4330 LRET=2		XTRP 148
GO TO 5000		XTRP 149
4340 Y3=A		XTRP 150
IF (Z3.NE.AZ) GO TO 8802		XTRP 151
Y = Y3		XTRP 152
GO TO 9999		XTRP 153
8802 LCZ=LCZ-K000FX		XTRP 154
KX1=KX1-K000FX		XTRP 155
KX3=KX3-K000FX		XTRP 156
NE=CV(LCZ-1)		XTRP 157
Z2=CV(LCZ)		XTRP 158
IF (CV(KX1)-AX) 4350,4350,4460		XTRP 159
4350 JX=LCZ+NE-1		XTRP 160
DO 4360 I=K>3,JX,2		XTRP 161
IF (CV(I)-AX) 4360,4365,4365		XTRP 162
4360 LRET=2		XTRP 163
GO TO 4500		XTRP 164
4365 IF (CV(I-2)-CV(I-4)) 4370,4640,4370		XTRP 165
4370 LRET=3		XTRP 166
GO TO 5000		XTRP 167

***CONTINUING

4375	Y2=A		XTRP	168
	IF(Z2.NE.AZ) GO TO 8803		XTRP	169
	Y = Y2		XTRP	170
	GJ TJ 9999		XTRP	171
9803	LCZ=LCZ-K000FX		XTRP	172
	KX1=KX1-K000FX		XTRP	173
	KX3=KX3-K000FX		XTRP	174
	NE=CV(LCZ-1)		XTRP	175
	Z1=CV(LCZ)		XTRP	176
	IF (CV(KX1)-AX) 4380,4380,4470		XTRP	177
4380	JX=LCZ+NE-1		XTRP	178
	DJ 4385 I=KX3,JX,2		XTRP	179
	IF (CV(I)-AX) 4385,4390,4390		XTRP	180
4385	CONTINUE		XTRP	181
	LRET=3		XTRP	182
	GJ TJ 4500		XTRP	183
4390	IF (CV(I-2)-CV(I-4)) 4395,4650,4395		XTRP	184
4395	LRET=1		XTRP	185
	GO TO 5000		XTRP	186
4099	Y1=A		XTRP	187
	IF(Z1.NE.AZ) GO TO 5500		XTRP	188
	Y = Y1		XTRP	189
	GJ TJ 9999		XTRP	190
C	EXTRAPOLATION		XTRP	191
4100	CV(3)=1.0		XTRP	192
	LCZ=7+2*K000FX		XTRP	193
	IF(CV(2)) 9999,9999,4030		XTRP	194
4200	CV(3)=1.0		XTRP	195
	LCZ=7+NZ*K000FX		XTRP	196
	IF (CV(2)) 9999,9999,4030		XTRP	197
4450	LRET=1		XTRP	198
	GJ TJ 4480		XTRP	199
4460	LRET=2		XTRP	200
	GJ TJ 4480		XTRP	201
4470	LRET=3		XTRP	202
4480	CV(3)=1.0		XTRP	203
	I=KX3		XTRP	204
	IF(CV(2)) 4490,9999,4490		XTRP	205
4490	GJ TJ (4325,4365,4390) ,LRET		XTRP	206
4500	CV(3)=1.0		XTRP	207
	I=JX		XTRP	208
	IF (CV(2)) 4510,9999,4510		XTRP	209
4510	GJ TJ (4325,4365,4390) ,LRET		XTRP	210
4630	I=I+2		XTRP	211
	GJ TJ 4330		XTRP	212
4640	I=I+2		XTRP	213
	GJ TJ 4370		XTRP	214
4650	I=I+2		XTRP	215
	GJ TJ 4395		XTRP	216
C	COMPUTE		XTRP	217
5000	CONTINUE		XTRP	218
	A=CV(I-3)+(AX-CV(I-4))*((CV(I-1)-CV(I-3))/(CV(I-2)-CV(I-4)))+(AX-CV(I-2))		XTRP	219
	1(I-2))/(CV(I)-CV(I-4))*((CV(I+1)-CV(I-1))/(CV(I)-CV(I-2))-(CV(I-1)-CV(I-2))		XTRP	220
	2)-CV(I-3))/(CV(I-2)-CV(I-4)))		XTRP	221
	GJ TJ (4099,4340,4375,1045) ,LRET		XTRP	222
5500	IF(CV(1).NE.5.0) GO TO 5502		XTRP	223
	IF(AZ.LT.Z2) GO TO 5501		XTRP	224

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      Z1 = Z2
      Z2 = Z3
      Y1 = Y2
      Y2 = Y3
5501 Y = (AZ-Z1) * (Y2-Y1)/(Z2-Z1) + Y1
      RETJRN
5502 Y=Y1+(AZ-Z1)*((Y2-Y1)/(Z2-Z1)+(AZ-Z2)/(Z3-Z1)*
      1 ((Y3-Y2)/(Z3-Z2)-(Y2-Y1)/(Z2-Z1)))
9999 RETURN
      END

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XTRP 225
XTRP 226
XTRP 227
XTRP 228
XTRP 229
XTRP 230
XTRP 231
XTRP 232
XTRP 233
XTRP 234

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***END

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13. ABSTRACT A computer program has been developed for predicting twin-nozzle/aftbody drag and internal nozzle performance for fighter type aircraft having twin buried engines and dual nozzles. The program is capable of generating the installed thrust-minus-drag data required for conducting mission analysis studies of aircraft of this type. The configuration variables which can be analyzed include (1) nozzle type (convergent flap and iris, convergent-divergent with and without secondary flow, and shrouded and unshrouded plug), (2) nozzle lateral spacing, (3) interfairing type (horizontal and vertical wedge), (4) interfairing length, and (5) vertical stabilizer type (single and twin). The performance prediction methods incorporated in the program are based almost entirely on empirical correlations. Specifically, correlations used in conjunction with one-dimensional flow relationships are employed for the prediction of the nozzle thrust and discharge coefficients, and correlations of the test data obtained during the contracted effort are employed for prediction of the aft-end drag. The prediction methods account for the effects of nozzle pressure ratio and flow separation on both internal and external nozzle surfaces. This manual describes the operation of the computer program in terms of program input requirements, performance prediction methods, and output format and includes a presentation of sample input/output cases and a complete computer listing of the program. The program has been developed for use on the CDC 6600 computer.			

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Airframe-Nozzle Integration						
Air Superiority Fighter Having Twin Buried Engines and Dual Nozzles						
Installed Nozzle Performance						
Nozzle Thrust Coefficient						
Nozzle Discharge Coefficient						
Aft-End Boattail Drag						
Twin-Nozzle/Aftbody Drag						
Design Criteria and Guidelines						
Turbojet/Turbofan						